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A taxonomic revision of the myrmecophilous species of the rattan genus *Korthalsia* (Arecaceae)

Salwa Shahimi^{1,2,3}, Maria Conejero², Christina J. Prychid², Paula J. Rudall², Julie A. Hawkins¹ & William J. Baker² 

Summary. The rattan genus *Korthalsia* Blume (Arecaceae: Calamoideae: Calameae) is widespread in the Malesian region. Among the 28 accepted species are 10 species that form intimate associations with ants. The ants inhabit the conspicuous ocreas that are produced by these species, using them as domatia to care for their young and aphids. As a foundation for future work, we present here a taxonomic treatment of the myrmecophilous *Korthalsia* species, based on extensive research pursued both in the herbarium and the field. In addition, we conduct detailed morphological characterisation of the structure and development of ocrea using light and scanning electron microscopy. Descriptions, illustrations, keys and distribution maps are presented for all 10 species, along with microscopic images of ocrea morphology and development for selected species.

Key Words. Ant-plant mutualism, Calamoideae, domatia, Malesia, morphology, myrmecophily, ocrea, taxonomy.

Introduction

Korthalsia Blume (1843) is one of the eight genera of rattans, which are spiny climbing palms in the subfamily Calamoideae (Baker *et al.* 2000; Couvreur *et al.* 2015; Vorontsova *et al.* 2016). The genus is distributed from northern Indochina, Burma and the Andaman Islands south-eastwards to Sulawesi and New Guinea (Dransfield *et al.* 2008). Currently, 28 species are accepted (WCSP 2017). The highest diversity of *Korthalsia* is found in Borneo, Malay Peninsula and Sumatra, with 15, nine and nine species respectively. *Korthalsia* is an isolated group within the Calamoideae, being the sole genus of subtribe Korthalsiinae in tribe Calameae of subfamily Calamoideae (Dransfield *et al.* 2008).

Korthalsia is highly distinctive among rattans in its morphology. It has a unique combination of characters, including (usually) diamond-shaped leaflets with jagged distal margins, aerially branching stems, hapaxanthic stems (that die after a single flowering event) and inflorescences with catkin-like rachillae. In addition, all species bear a conspicuous extension of the leaf sheath above the point of attachment of the leaf petiole. This structure, known as an ocrea, is diverse in form in *Korthalsia*. Dransfield (1981) classified the ocreas of *Korthalsia* into four types: inflated, divergent, tightly sheathing and fibrous net-like.

The ten species of *Korthalsia* that possess either inflated or divergent ocreas form mutualistic

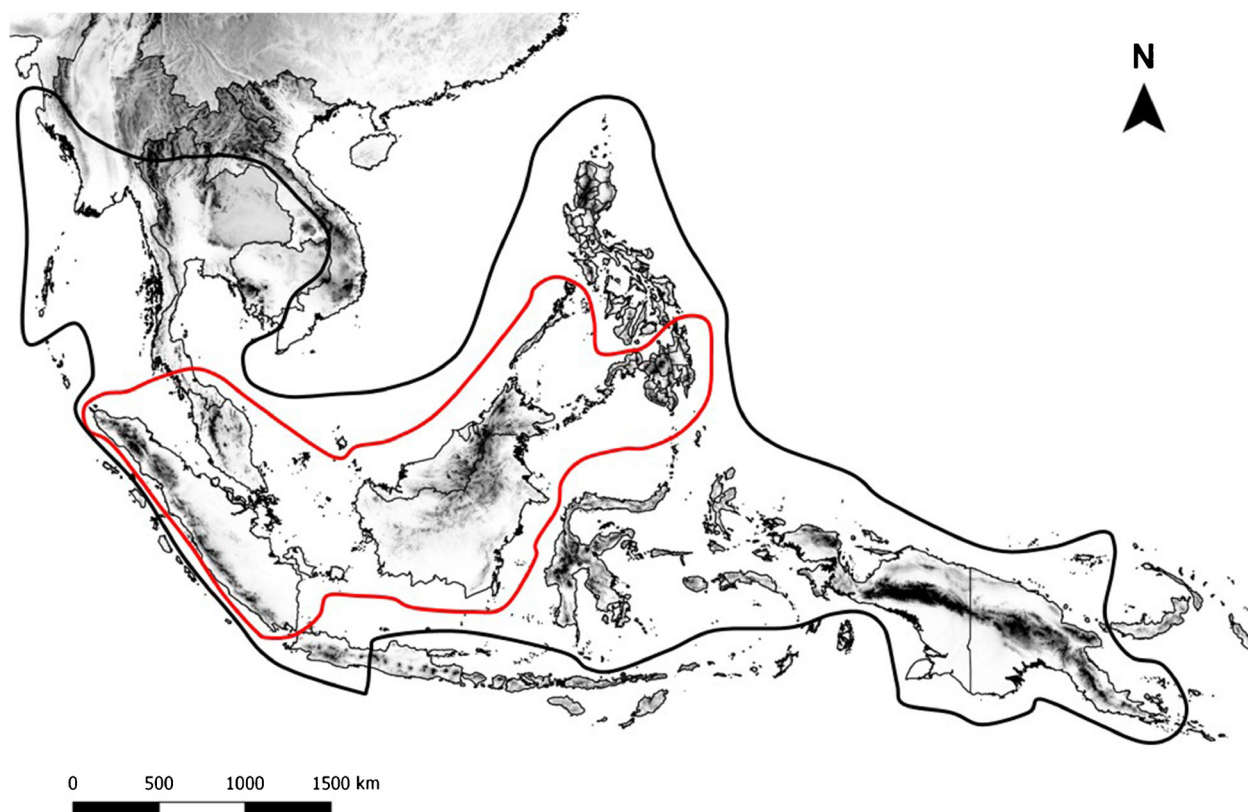
relationships with ants, which exploit the ocreas as domatia (Dransfield *et al.* 2008). The ants nest within the ocreas, brooding their young and aphids from which they harvest honeydew. The ants defend the rattan by attacking any animal that disturbs it. In addition, ants that occupy the two species with divergent ocreas (*K. hispida* and *K. robusta*) make a pulsing, hissing sound when the rattan is disturbed by rhythmically striking their mandibles against the dry wall of the ocrea. Several ant genera have been recorded inhabiting *Korthalsia* ocreas: *Camponotus*, *Crematogaster*, *Dolichoderus*, *Iridomyrmex* or *Philidris* (Bequaert & Wheeler 1922; Dransfield 1981; Mattes *et al.* 1998; Moog *et al.* 2003; Edwards *et al.* 2010; Chan *et al.* 2012). This association does not occur throughout the distribution of *Korthalsia*, the myrmecophilous species being restricted to Borneo, Malay Peninsula, Philippines (Palawan and Mindanao), Singapore and Thailand (Map 1). Although phylogenetic evidence is limited for *Korthalsia*, recent data indicate that the species with inflated and divergent ocreas are closely related to each other, potentially forming a monophyletic group (Shahimi 2018). Curiously, inflated ocreas occupied by ants occur in other rattan genera, specifically the African genus *Laccosperma* (Sunderland 2004, 2012) and some species of *Calamus*, especially on the island of New Guinea (e.g. Baker & Dransfield 2002; Dransfield & Baker 2003; Merklinger *et al.* 2014).

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Map 1. Distribution map of the genus *Korthalsia* in the Malesian region (black line). The distribution of the myrmecophilous species is shown with a red line.

The genus *Korthalsia* has been known to scientists for nearly two centuries, having been first described in 1843 by Carl Ludwig Blume. However, the last treatment of the genus in its entirety was published 100 years ago (Beccari 1918), building on a series of earlier contributions (Beccari 1884, 1893, 1909). Since that time, a synoptic treatment has been published (Dransfield 1981), as well as a series of regional accounts (Furtado 1951; Dransfield 1979, 1984, 1992, 1997; Henderson 2009; Lapis 2010) and some new species (Dransfield 1981; Henderson & Nguyen 2013), but no complete, modern taxonomic revision has yet been produced. Here we address this knowledge gap by presenting a taxonomic account of the myrmecophilous species of *Korthalsia* across their entire geographical range. We focus especially on the structural biology of the ocrea, characterising its morphology and development with light and scanning electron microscopy. This revision will serve as a valuable tool and data source for those with special interests in the ecology and evolution of ant-plant mutualism in *Korthalsia* (e.g. Mattes *et al.* 1998; Edwards *et al.* 2010; Chan *et al.* 2012). Moreover, it represents a contribution towards the completion of a monograph of all species currently recognised in the genus.

Material and Methods

Taxonomy

An extensive study of specimens at the Kew herbarium (K) and three international herbaria, namely E, KEP and SING (herbarium acronyms follow Holmgren *et al.* 1990) underpins this study. Specimen images available online in other institutions were also consulted. Exclamation marks in the taxonomic treatment (!) indicate specimens that have been studied by the authors (including online specimen images). In addition, the first author has conducted two field expeditions in 2014 and 2015, visiting Peninsular Malaysia and Singapore, then Borneo and Singapore. Herbarium specimens were made in the field using standard preparation guidelines for palms (Dransfield 1986; Baker & Dransfield 2006).

Characterisation of ocrea morphology and development

Korthalsia stem apices measuring c. 1 m in length were collected in the field and fixed in 70% ethanol. Each shoot was carefully dissected by removing leaf sheaths until the shoot was approximately the diameter of a pencil. Images of later stages of development were captured with a photomicroscope. For examination of

early leaf development close to the stem apex, we used Scanning Electron Microscopy (SEM). Dissected samples were dehydrated through an alcohol series to 100% ethanol. The samples were transferred to an Autosamdri 815B CPD for critical-point drying, mounted onto SEM pin stubs using double-sided tape, and coated with platinum using an Emitech K550 sputter coater. Samples were examined using a Hitachi S-4700 cold-field emission SEM at RBG Kew. Ocrea morphology was also studied using a Leica photomicroscope M400 (Light Microscopy).

Results

Habit

The myrmecophilous species of *Korthalsia* are moderate to robust, clustering, high-climbing rattans up to 60 m or more. Some species can reach the forest canopy. They are found only in lowland and hill tropical forest, being absent in montane forest. Most of the species have a wide ecological range and are abundant in primary forest.

Stem

The stem size of myrmecophilous *Korthalsia* varies from slender (0.2 – 0.8 cm in diameter without sheath) to moderately large (1.0 – 4.0 cm in diameter without sheath). The internodes are elongate and variable in length. Nodal scars of *Korthalsia* species are often uneven. Aerial branching sometimes occurs due to parallel forking of stems.

Leaves

The leaf sheath is tubular, green and usually with caducous indumentum. The sheath is sometimes unarmed or variously armed with spines. The petiole ranges from 1.5 cm to 40 cm. The leaflets are regularly arranged and usually rhomboid with distal margins praemorse, but in few species (e.g. *Korthalsia echinometra*), they are lanceolate, although still with a praemorse distal margin. The adaxial surface of the leaflets is usually bright or dark green, and the abaxial surface is typically covered in white or grey indumentum, or sometimes with caducous, orange or brown to dark brown indumentum. The number of leaflets on each side of the rachis varies from one to 25, with the smallest number belonging to *K. furcata* and the highest in *K. echinometra*. The main veins diverge from the leaflet base. All species of *Korthalsia* have leaves armed with a cirrus, a leaf whip extending beyond the terminal leaflets.

Ocrea

We examined ocrea development in four species of myrmecophilous *Korthalsia* for which fixed material was available, representing both inflated and divergent

ocrea types (*sensu* Dransfield 1981): inflated ocrea (*K. echinometra*, *K. scortechinii*, and *K. rostrata*), divergent ocrea (*K. robusta*). For comparison, we also examined three species with the tightly sheathing ocrea type (*K. debilis*, *K. rigida* and *K. tenuissima*). The fibrous net-like ocrea type is found only in *K. jala*, which was not encountered during our fieldwork and fixed material was not available (Fig. 1).

The three species examined with inflated ocreas (Fig. 2A – C) differ in the origin of the inflation. *Korthalsia echinometra* (Fig. 2A) shows inflation from the point of attachment of the ocrea to the leaf sheath, whereas in the other two species (Fig. 2B, C) the ocrea is tightly clasping at the base and inflated above. At the stage recorded in Fig. 2, the tightly clasping part is almost as long as the inflated part, although in the mature ocrea the clasping part is relatively shorter. *Korthalsia echinometra* also differs from *K. scortechinii* and *K. rostrata* in that it lacks the notch that forms in the ocrea apex of *K. scortechinii* and *K. rostrata*. In contrast, the apex is truncate in the species in which the ocrea is tightly sheathing for its entire length (*K. debilis* and *K. rigida*; Fig. 2E – F). In some species, spines cover the ocrea at an early stage (Fig. 2A – D), whereas in others they are absent (Fig. 2E – F).

At an earlier stage, the degree of ocrea inflation differs between *Korthalsia echinometra*, *K. scortechinii* and *K. rostrata* (Fig. 3A – C). At this stage, there is slight inflation of the leaf base in *K. echinometra* (Fig. 3A), no inflation in *K. scortechinii* (Fig. 3B) and clear inflation in *K. rostrata* (Fig. 3C). The bifid ocrea apex is clearly visible at this stage in *K. rostrata* (Fig. 3C). Small spines are also visible at this stage on the ocrea of *K. robusta* (Fig. 3D) and a few small rounded spines were visible in *K. debilis* (Fig. 3E), although none was present in *K. tenuissima* (Fig. 3F).

Young leaf primordia at successive stages were examined for *Korthalsia echinometra* (Fig. 4) and *K. debilis* (Fig. 5), representing the inflated and tightly sheathing ocrea type respectively. In both species, early stages of leaf plication are evident (Fig. 4B, 5A), although the ocrea lacks plications in either species at any stage. In both species, the ocrea becomes visible at a relatively late stage (Fig. 4D, 5D).

Inflorescence

The flowering behaviour in all species of *Korthalsia* is hapaxanthic (individual stems flower only once in their lifetime and die subsequently). The inflorescences are borne at the apex of the stem and are lax to congested, with one to two orders of branching. The peduncle is adnate to the internode above the subtending leaf (Dransfield *et al.* 2008). The prophyll is 2-keeled and tightly sheathing. Rachis bracts are similar to the prophyll, but lack keels and are somewhat inflated in some species.



Fig. 1. Images taken in the field of the leaf bases of six species of *Korthalsia* with different ocrea types. A *K. echinometra*, inflated ocrea; B *K. rostrata*, inflated ocrea; C *K. robusta*, divergent ocrea; D *K. debilis*, tightly sheathing ocrea; E *K. rigida*, tightly sheathing ocrea; F *K. jala*, fibrous net-like ocrea. PHOTOS: A, B WILLIAM BAKER, C – E SALWA SHAHIMI, F JOHN DRANSFIELD.

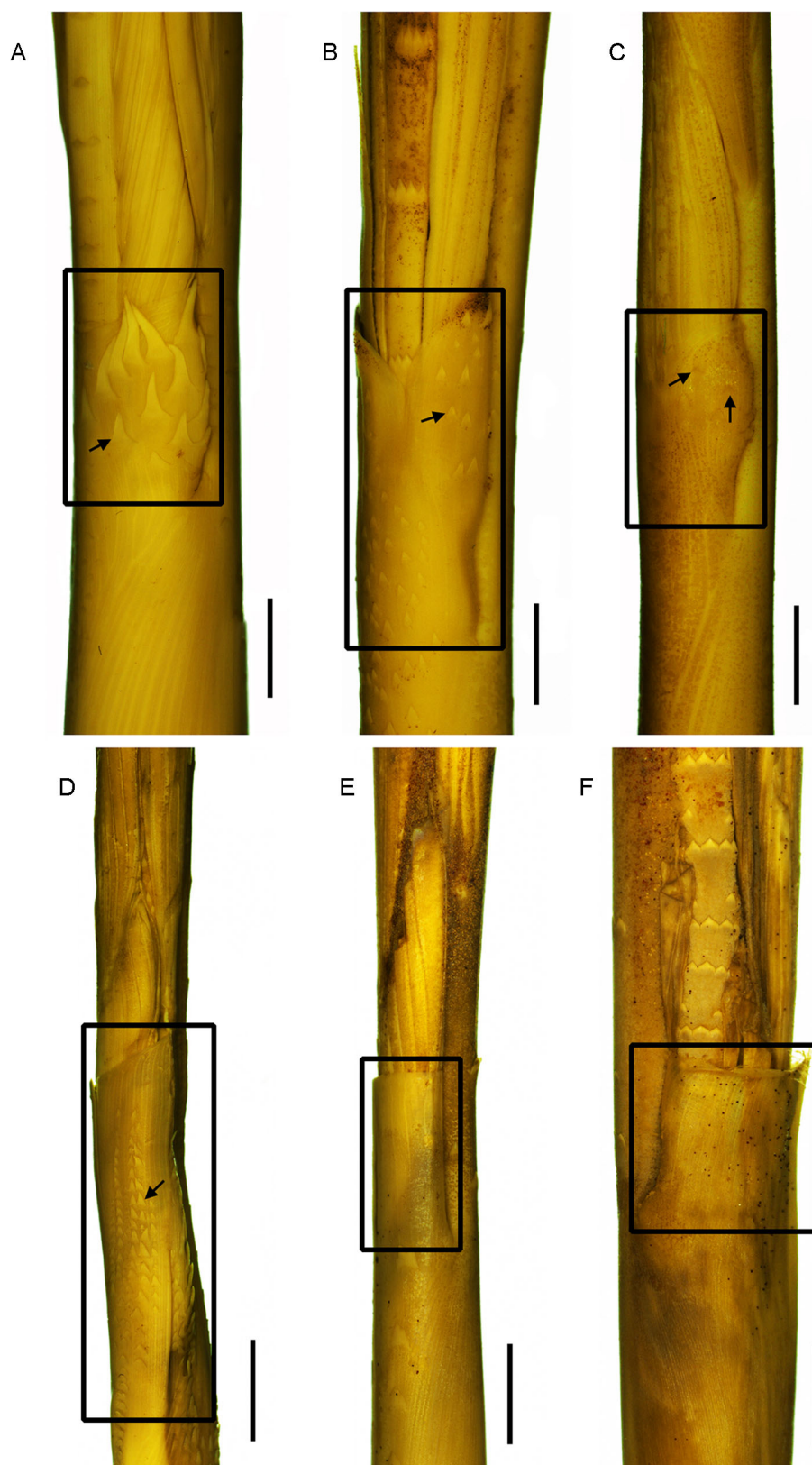


Fig. 2. Photomacroscopic images of leaf bases in fixed material. A – C represent species with an inflated ocrea, D a divergent ocrea, E – F a tightly sheathing ocrea. A *Korthalsia echinometra*; B *K. scortechinii*; C *K. rostrata*; D *K. robusta*; E *K. debilis*; F *K. rigida*. Boxed areas outline the region of the developing ocrea. Arrows indicate spines. Bar = 10 mm.

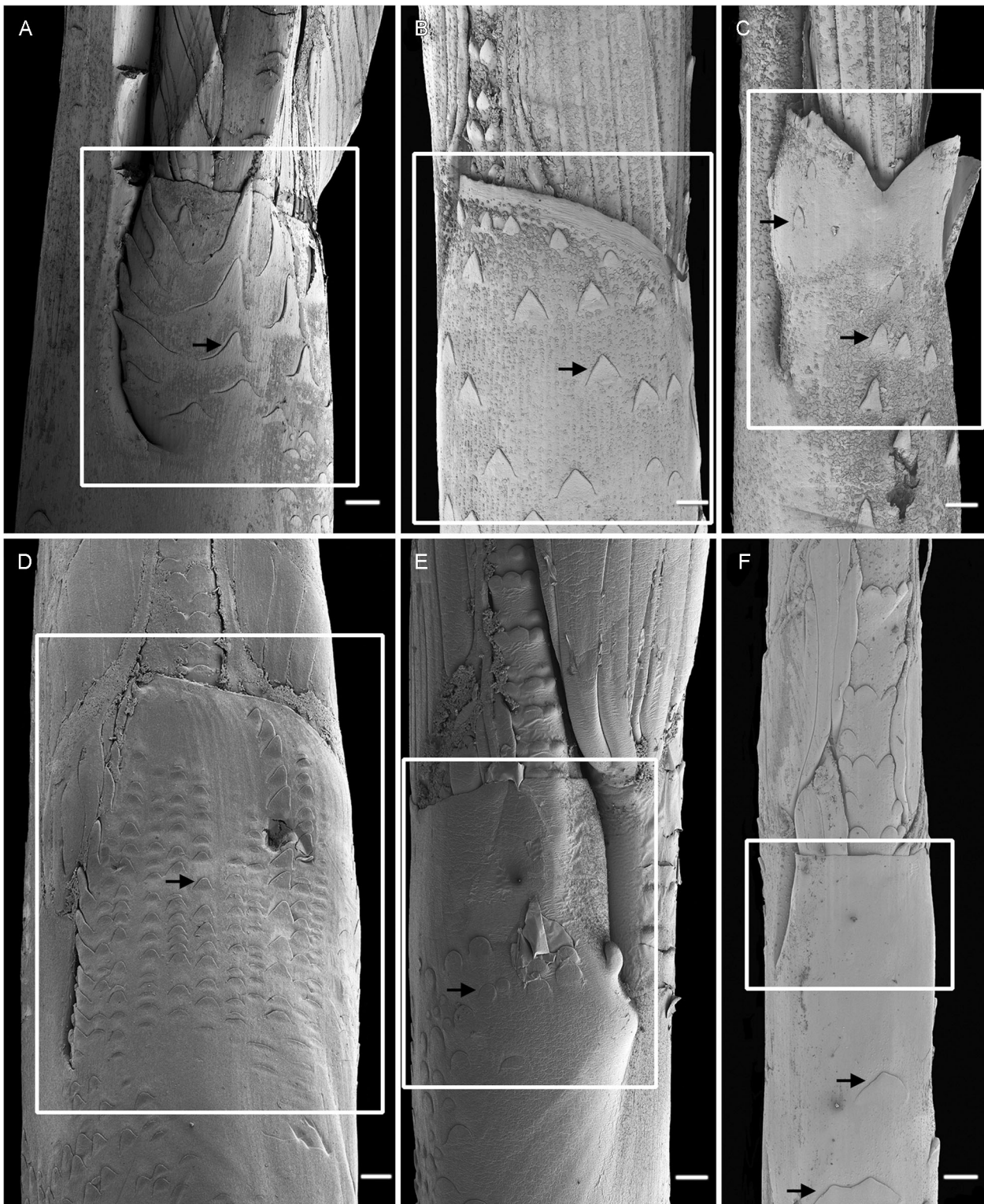


Fig. 3. SEM images of dissected bases of very young leaves, showing early stages of ocrea development. A – C represent species with an inflated ocrea, D a divergent ocrea, E – F a tightly sheathing ocrea. A *Korthalsia echinometra*; B *K. scortechinii*; C *K. rostrata*; D *K. robusta*; E *K. debilis*; F *K. tenuissima*. Boxed areas outline the region of the developing ocrea. Arrows indicate spines. Bars = 100 μm.

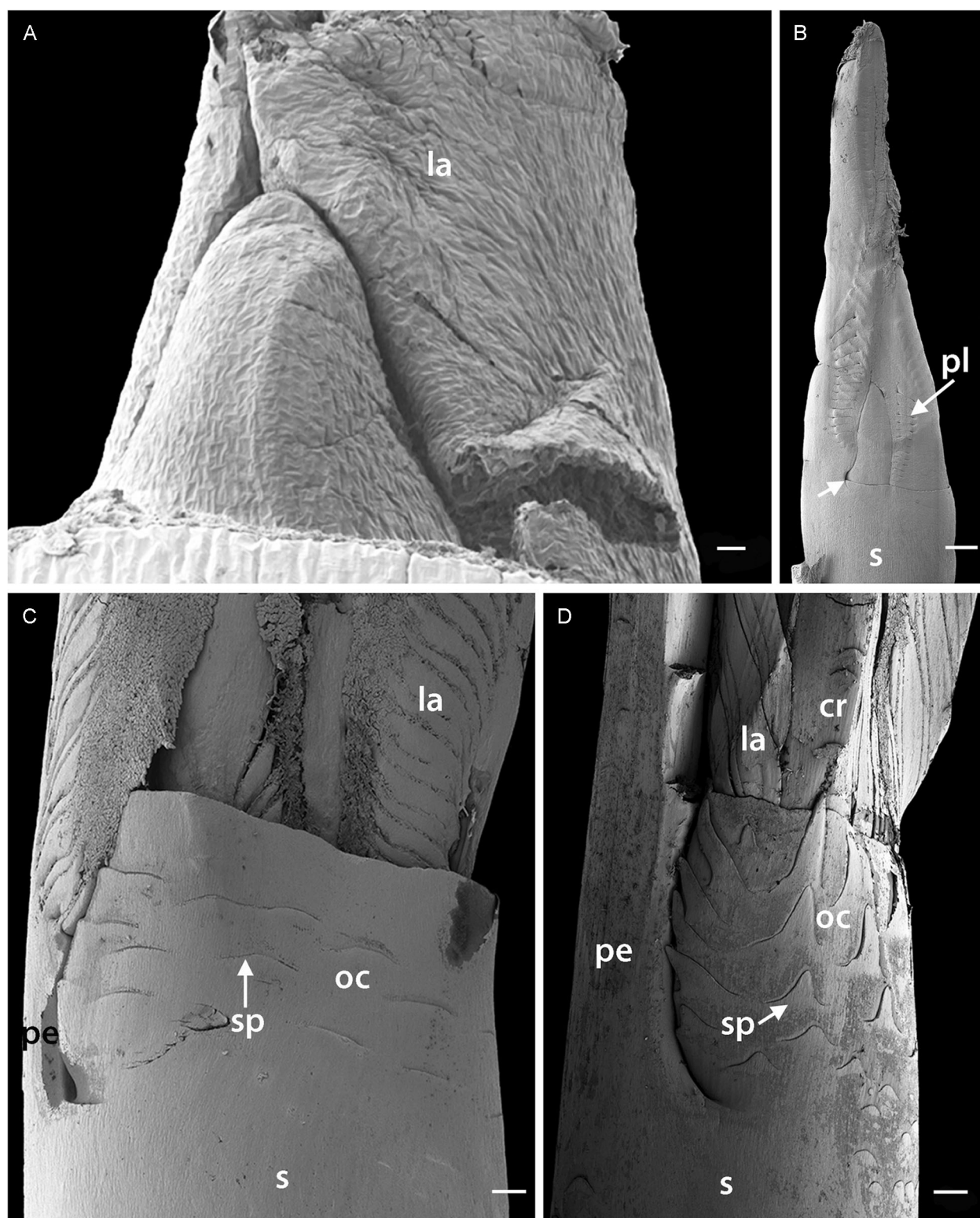


Fig. 4. Leaf developmental series (SEM). **A** – **D** developmental stages for *Korthalsia echinometra*, a species with an inflated ocrea. **A** leaf primordium differentiated into a distal lamina but lacking plications at this stage; **B** successive stages of leaf elongation, with leaf plication becoming more pronounced on both sides of the lamina and small lobes present at the top of the leaf sheath (arrow) indicating the first stage of ocrea development; **C** at this stage, the petiole has begun to elongate, the spines have begun to develop and the ocrea is more clearly visible; **D** the ocrea is a well-delimited structure that will persist into the adult organ. Bars = 100 μ m. la lamina, s sheath, sp spines, pe petiole, pl leaf plications, oc ocrea.

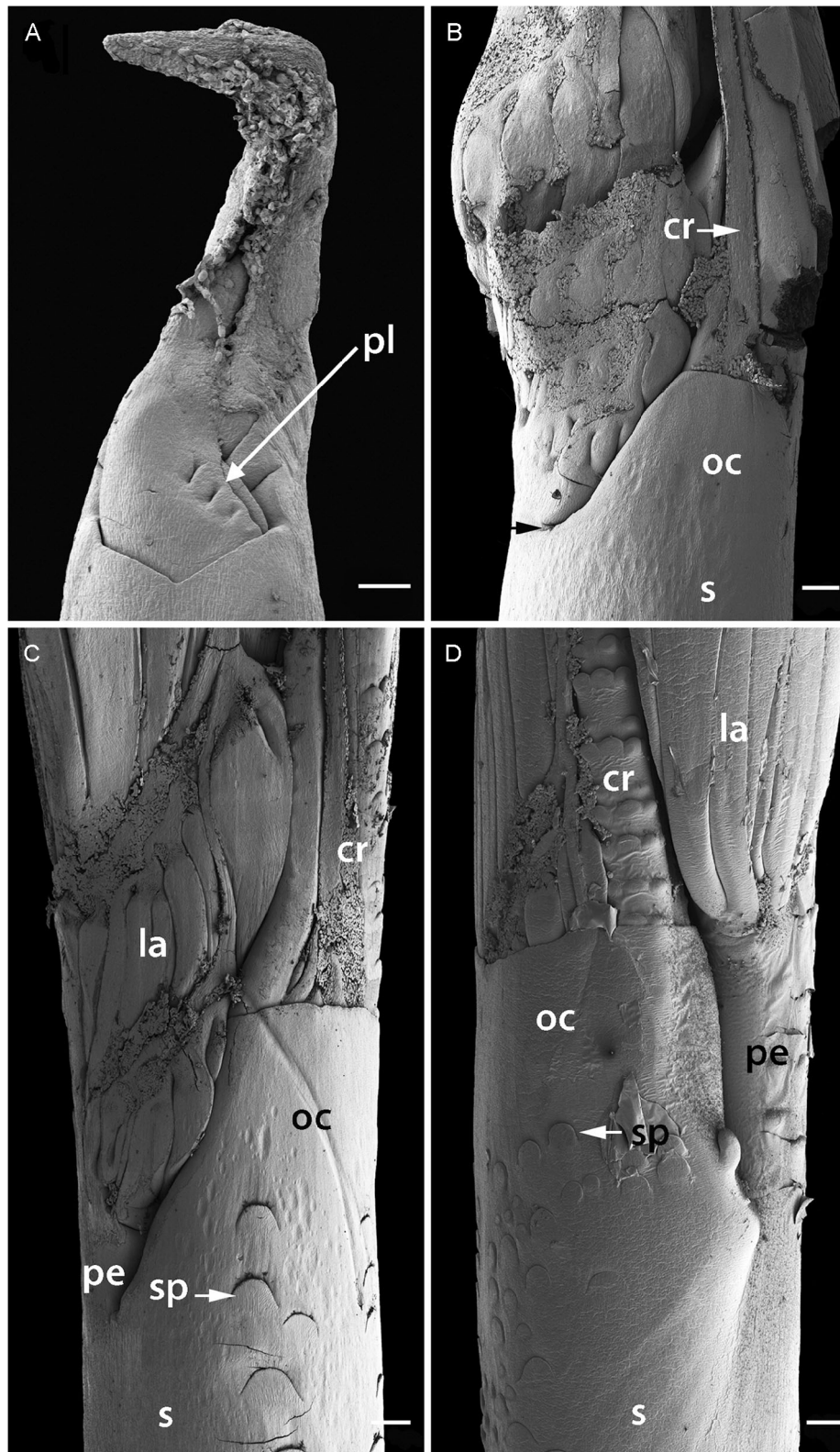


Fig. 5. Leaf developmental series (SEM). A – D developmental stages for *Korthalsia debilis*, a species with a tightly sheathing ocrea. A plication inception is visible on the leaf; B the cirrus is visible above the petiole (arrow); C at this stage, the petiole has begun to elongate, the spines have begun to develop and the ocrea has become more visible; D the ocrea is a well-delimited structure that will persist into the adult organ. Bars = 100 μ m. s sheath, sp spines, cr cirrus, pe petiole, pl leaf plications, oc ocrea.

The bracts can be unarmed or sparsely armed and densely covered with caducous indumentum. The rachillae are cylindrical and catkin-like, with densely arranged rachilla bracts, sometimes with hairs in between. The rachillae can be slender or congested.

Flowers

In all *Korthalsia* species, the flower is hermaphroditic and borne in pits in the catkin-like rachillae. Unlike many other calamoid palms, the flower is solitary, rather than borne in pairs. The calyx is tubular at the base, with three sepals and usually shorter than corolla. The corolla consists of three valvate petals. The flower contains 6 – 9 stamens.

Fruits and Seeds

The fruit of *Korthalsia* species examined here is globose to ovoid, with one seed. The epicarp is thin and covered with vertical rows of imbricate scales. The scales are usually brown to straw-coloured. The mesocarp develops as a thin sweet-fleshy layer surrounding the seed, and the endocarp is not differentiated. Unlike most species of tribe Calameae, the seed lacks a sarcotesta. The seed is attached basally. In most of the species, the endosperm is ruminant, but in a few species (e.g. *K. hispida*) the endosperm is homogeneous. The fruits of most species appear to be attractive to animals (Dransfield 1981).

Taxonomic Treatment

Key to myrmecophilous species of *Korthalsia*

1. Ocrea not clasping, diverging at an angle from the stem, margins tending to inroll (Borneo, Peninsular Malaysia, Philippines) 2
 Ocrea clasping the stem and inflated (Borneo, Peninsular Malaysia, Sumatra, Singapore, Thailand, Philippines) 3
2. Ocrea 18.5 – 30.0 × 3.0 – 4.5 cm long, ocrea, sheath and inflorescences bracts with abundant black spicules (Borneo, Peninsular Malaysia, Sumatra) ***K. hispida***
 Ocrea 16.0 – 40.0 × 3.0 – 7.0 cm long, ocrea, sheath and inflorescences bracts without black spicules absent (Borneo, Philippines, Sumatra) ***K. robusta***
3. Leaflets rhomboid (rarely narrowly rhomboid) 4
 Leaflets narrowly lanceolate (Borneo, Peninsular Malaysia, Singapore, Sumatra) ***K. echinometra***
4. Leaflets only one on each side of the rachis (Sarawak) ***K. furcata***
 Leaflets usually more than three on each side of rachis 5
5. Stem slender, with sheath less than 1.5 cm diam 6
 Stem robust, with sheath at least 2.0 cm diam 8
6. Leaflets densely indumentose on undersurface (Philippines) ***K. scaphigeroides***
 Leaflets sparsely indumentose on undersurface 7
7. Ocrea 2.5 – 5.0 × 1.0 – 3.0 cm, transverse veinlets moderately closely spaced, rachillae slender (Peninsular Malaysia, Borneo, Singapore, Sumatra) ***K. rostrata***
 Ocrea 2.5 – 8.3 × 1.0 – 1.5 cm, transverse veinlets fine and closely spaced, rachillae robust and congested (Borneo) ***K. furtadoana***
8. Ocrea armed with scattered triangular spines up to 2.0 cm long and ocrea about 20 – 26 cm long 9
 Ocrea armed with scattered very short triangular spines about 3 mm long and ocrea about 10 – 15 cm long (Peninsular Malaysia, Thailand) ***K. scortechinii***
9. Leaflets rhomboid to broadly rhomboid, 6 – 8 leaflets each side of rachis and petiole 10 – 25 cm long (Borneo) ***K. cheb***
 Leaflets rhomboid, 7 – 12 leaflets each side of rachis and very long petiole c. 40 cm long (Borneo) ***K. angustifolia***

1. ***Korthalsia angustifolia*** Blume (1843: 172). Type: Indonesia, South Kalimantan, Sungai Dusun, *Korthals & Muller* s.n. (holotype L!; isotype FI!).

Clustering rattan climbing to 50 m. *Stem* with sheaths 35 – 50 mm diam., without sheaths 20 – 30 mm diam.; internodes 10 – 25 cm. *Leaf* 2 – 3 m long including cirrus and petiole; sheath green, with grey indumentum, sheath sparsely armed with brown to

dark brown triangular spines, spines more abundant near sheath mouth, spines 3 – 13 mm long, c. 1 mm wide; ocrea 24.2 – 25.5 × 2.5 – 3.5 cm, very large and conspicuous, elongate inflated, clasping the stem, tough, brown (when dry), armed with 1.0 – 2.0 cm long dark brown, planar spines, ocrea occupied by ants; cirrus c. 1 m; petiole c. 40 cm, 10 – 15 mm wide and 3 – 4 mm thick at base, flattened adaxially, abaxially rounded, with grey indumentum as sheath,

sparsely armed with spines; rachis c. 0.9 m, armed with recurved grapnel spines organised in whorls; 7 – 12 leaflets each side of rachis, regularly arranged, rhomboid, mid-leaf leaflets $18.0 - 23.0 \times 4.7 - 5.9$ cm, leaflet dark green above, glabrous, with caducous, grey-brown indumentum on undersurface, distal margin conspicuously praemorse, transverse veinlets moderately conspicuous, moderately spaced c. 1.0 mm. *Inflorescence* lax, 47.0 – 61.7 cm long, branched to 2 orders; rachis bracts up to $6.2 - 7.0 \times 3.5 - 3.7$ cm, tightly sheathing and splitting, with caducous, dark brown indumentum; primary branches 1 – 2, 4.0 – 8.0 cm apart, proximal primary branch 20.2 – 22.1 cm long, with up to 2 rachillae; rachillae 17.8 – 24.8 cm long, including 1.5 – 3.7 cm visible stalk, 0.7 – 1.0 cm wide, densely hairy between rachilla bracts. *Flower* not seen. *Fruit* mature fruit not seen. *Seed* not seen. (Fig. 6).

DISTRIBUTION. Borneo (Central and South Kalimantan) (Map 2).

SPECIMENS EXAMINED. BORNEO. INDONESIA. KALIMANTAN TENGAH: Palangka Jaya, [2°12'S 113°50'E], 25 Jan. 1974, *Dransfield* 3924 (K!, L). **KALIMANTAN SELATAN:** Barito R., 12 km upstream of Marabahan, [2°50'S 114°29'E], 3 Jan. 1989, *Geisen* 89 (K!); Sampit, Sei Pemalian, [2°32'S 112°57'E], July 1986, *Sutisna* 70 (K!); Sungai Dusun, [1°48'S 114°31'E], *Korthals & Muller* s.n. (FI!, L!).

HABITAT. Along river banks and in freshwater swamp on alluvial soils.

VERNACULAR NAMES. *Ahas*, *Rotan ahas*, *Rotan patung* (Indonesia).

USES. Not recorded.

NOTES. Very little herbarium material of *Korthalsia angustifolia* is available. Although *K. angustifolia* is vegetatively very similar to *K. cheb* and *K. scortechinii*, it has a very long petiole compared to *K. cheb* and *K. scortechinii*.

2. *Korthalsia cheb* Becc. (Beccari 1884: 67). Type: Malaysia, Sarawak, Gunung Matang, 1 June 1866, *Beccari* PB 1936 (holotype FI!).

Robust, clustering rattan climbing to 30 m. *Stem* with sheaths 20 – 40 mm diam., without sheaths 10 – 25 mm diam.; internodes 25 – 30 cm. *Leaf* 2.2 – 3.5 m long including cirrus and petiole; sheath bright green, almost completely obscured by ocrea, with caducous, black indumentum, sheath sparsely armed with brown, triangular spines, spines 7 – 12 mm long, c. 2 mm wide; ocrea $20.0 - 26.0 \times 5.0 - 8.0$ cm, very large and conspicuous, tightly sheathing above the petiole then inflated, clasping the stem, tough, brown, armed with 6 – 26 mm long, dark brown, planar spines, ocrea occupied by numerous ants, entry hole made by ants

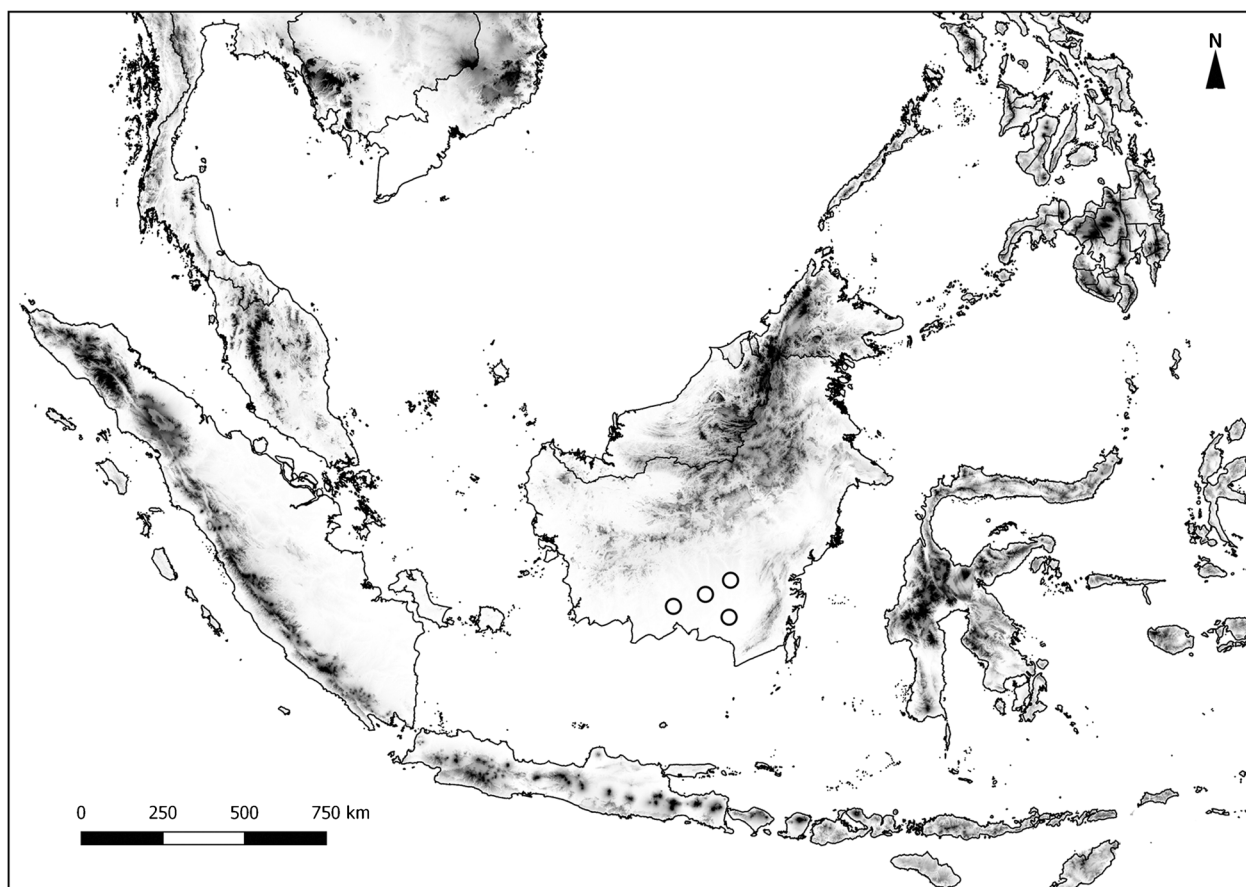
often visible; cirrus 0.7 – 1.0 m, armed with recurved grapnel spines organised in whorls; petiole 10 – 25 cm, 14 – 18 mm wide and 4 – 5 mm thick at base, flattened adaxially, abaxially rounded, with brown indumentum, armed with spines as sheath; rachis 0.80 – 2.03 m, armed with recurved grapnel spines organised in whorls; 6 – 8 leaflets each side of rachis, regularly arranged, rhomboid to broadly rhomboid, mid-leaf leaflets $20.8 - 27.3 \times 4.3 - 7.7$ cm, leaflet light to dark green above, brownish undersurface covered with caducous, orange brown indumentum when young, distal margin conspicuously praemorse, transverse veinlets conspicuous, moderately closely spaced c. 1.5 mm. *Inflorescence* lax, 52.9 – 54.0 cm long including 11.5 cm peduncle, branched to 2 orders; prophyll $4.5 - 6.5 \times 0.8 - 1.8$ cm; rachis bract $2.0 - 8.7 \times 1.9 - 2.3$ cm, tightly sheathing, with caducous, dark brown indumentum; primary branches 1 – 2, 0.5 – 1.0 cm apart, proximal primary branch 16.8 – 21.0 cm long, with 1 – 4 rachillae; rachillae 13.5 – 23.6 cm long and slender including 0.5 – 1.5 cm visible stalk, 0.5 – 1.0 cm wide, densely hairy between rachilla bracts. *Flower* 4×2 mm in the bud. *Fruit* somewhat oblong, $1.4 - 2.2 \times 0.9 - 1.8$ cm covered in 16 – 18 vertical rows of yellow-brown scales. *Seed* 1.2×0.1 cm; endosperm ruminate. (Fig. 7).

DISTRIBUTION. Borneo (in the 1st Division of Sarawak, Sabah, East and South Kalimantan) (Map 3).

SPECIMENS EXAMINED. BORNEO. INDONESIA. KALIMANTAN TIMUR: Gunung Mendam at foot north of Tabang, 100 m elev., [0°37'N 115°54'E], 16 Jan. 1979, *Mogea et al.* 1630 (K!); Surroundings of Long Sungai Barang, 800 m elev., [1°40'N 115°0'E], 30 Dec. 1992, *van Valkenburg* 1206 (K!). **KALIMANTAN SELATAN:** Gunung Besar, 800 m elev., [2°43'S 115°37'E], 19 Feb. 1979, *Mogea et al.* 1686 (K!). **MALAYSIA. SABAH:** Tambunan, Crocker Range National Park NW of Kampung Kuyongon close to Tundulu R., 950 m elev., [5°40'N 116°20'E], 13 Sept. 2000, *Andersen* 175 (C, K!, KEP, SAN); Tambunan, Mile 8, road to Kampung Kaingaran, 1150 m elev., 26 March 1999, *Dewol SAN* 141821 (K!, SAN); Kota Kinabalu, Mile 24, Sinsuron Road, Crocker Range, 800 m elev., 21 Aug. 1979, *Dransfield et al.* 5535 (K!, L, SAF, SAR); Ranau, Kampung Bundu Tuhan, [5°59'N 116°32'E], 8 Jan. 1994, *Soibeh* 683 (K!). **SARAWAK:** Kapit, Batang Balleh, [1°50'N 113°40'E], 16 July 1987, *Lee S* 54592 (K!, L); Kapit, Belaga, 200 m elev., [1°55'N 111°11'E], 9 Aug. 1975, *Dransfield et al.* 4671 (K!, KEP); Kuching, 1st Division, Gunung Matang, 750 m elev., 9 April 1981, *Dransfield et al.* 5882 (K!, L, NY, PNH); Gunung Matang, [1°36'N 110°10'E], 1 June 1866, *Beccari* PB 1936 (FI!); Kuching, 1st Division, Kampung Kakeng, 200 m elev., [1°9'N 110°27'E], 20 July 1993, *Bunker* 51 (K!); Kuching, Lundu, Waterfall trail Gunung Gading,



Fig. 6. *Korthalsia angustifolia*. A ocrea (Sutisna 070); B inflorescence (Giesen 89); C leaflets (Sutisna 070).



Map 2. Distribution of *Korthalsia angustifolia*. Dots are point localities of specimens examined.

300 m elev., 25 April 1996, *Baker* 742 (K!, KEP, SAN, SING!); Kuching, Siburan, Semenggoh Arboretum, [1°24'N 110°18'E], 9 Feb. 1995, *Baker* 513 (K!, KEP).

HABITAT. Hill dipterocarp forest at altitudes up to 800 m, usually in humid valleys.

VERNACULAR NAMES. *Wee jematang tengah* (Kayan), *Lasas* (Petung), *Wae dura* (Penan), *Uei sanam* (Kenyah), *Rua* (Bidayuh).

USES. Making baskets, as binding material for constructing pig-sties.

NOTES. *Korthalsia cheb* is a very distinctive species with its very large inflated ocrea and broad diamond-shaped (rhomboid) leaflets. It can be confused with *K. angustifolia*.

3. *Korthalsia echinometra* Becc. (Beccari 1884: 66). Type: Malaysia, Sarawak, Gunung Matang, 1 June 1866, *Beccari* PB 1935 (holotype FI!).

Korthalsia angustifolia var. *gracilis* Miq. (Miquel 1868: 16). Type: Indonesia, Sumatra, Palembang, *De Vriese* (holotype L).

Korthalsia horrida Becc. (Beccari 1884: 66). Type: Malaysia, Sarawak: Gunung Matang, 1 June 1866, *Beccari* PB 1918 (holotype FI!).

Daemonorops ochreata Teijsm. & Binn. (Teijsmann & Binnendijk 1866: 74), nom. inval.

Calamus ochreatus Miq. (Miquel 1868: 29), nom. inval.

Moderately robust, clustering rattan climbing to 50 m. Stem with sheaths 12 – 35 mm diam., without sheaths 9 – 20 mm diam.; internodes 12 – 25 cm. Leaf 1.0 – 2.5 m long including cirrus and petiole; sheath green, almost entirely obscured by ocrea, with indumentum grey in colour, sheath sparsely armed with scattered, brown triangular spines, spines more abundant near sheath mouth, spines 2 – 20 mm long, 1 – 3 mm wide; ocrea 6.0 – 15.5 × 3.5 – 5.0 cm, conspicuous, inflated and elongate, clasping the stem, tough, brown, armed with 1.0 – 7.7 cm long, dark brown to black, planar spines, ocrea occupied by numerous ants, entry hole made by ants often visible; cirrus 0.75 – 1.80 m, armed with recurved grapnel spines organised in whorls; petiole 5.0 – 40.0 cm, 7 – 20 mm wide and 3 – 5 mm thick at base, flattened adaxially, abaxially rounded, with caducous, brown indumentum, sparsely armed with spines; rachis 0.49 – 1.50 m, armed with recurved grapnel spines at base and then the spines organised in whorls before the cirrus; 8 – 25 leaflets each side of rachis, regularly arranged, narrowly lanceolate, mid-leaf leaflets 24.6 – 31.4 × 1 – 2 cm, leaflets dull to dark

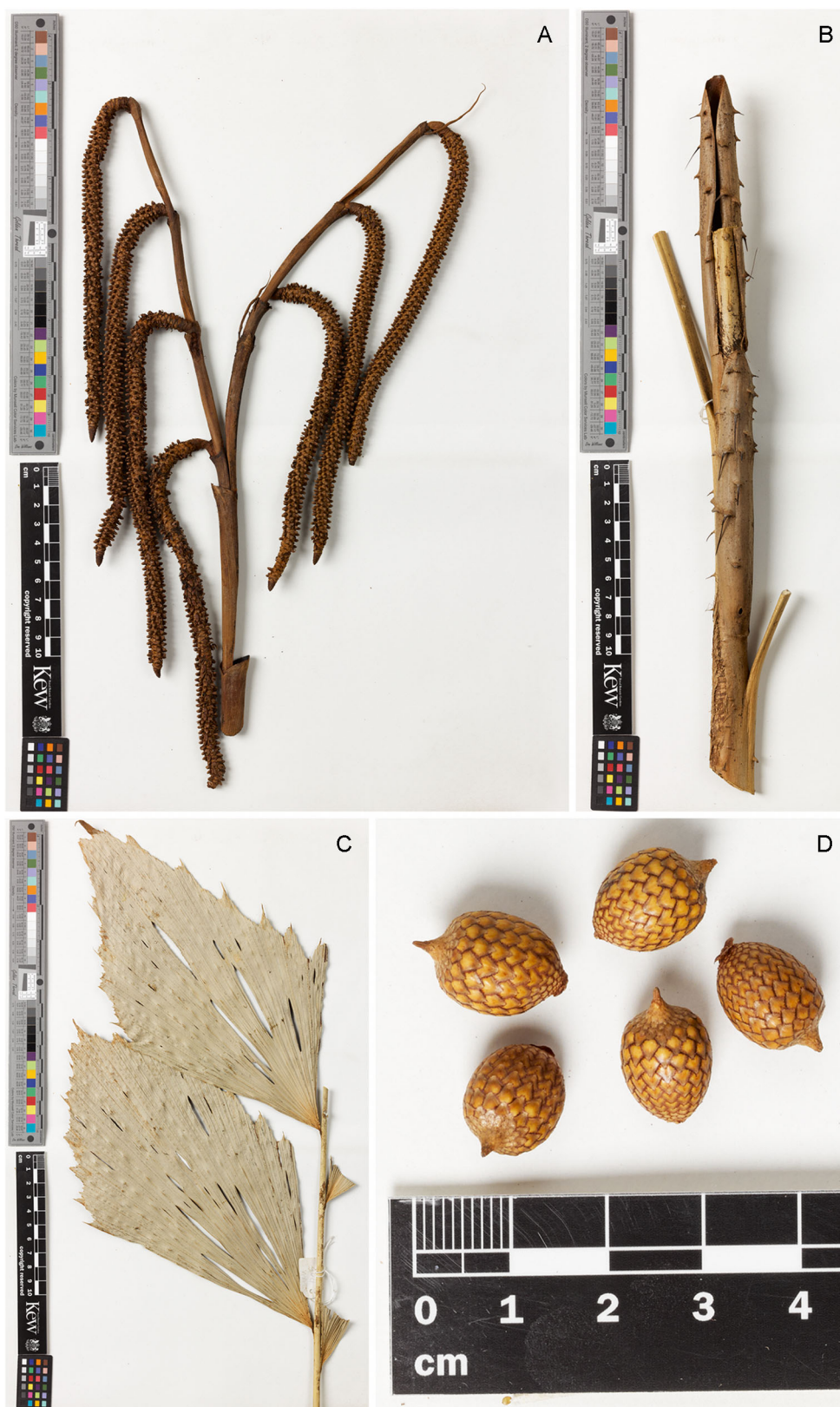
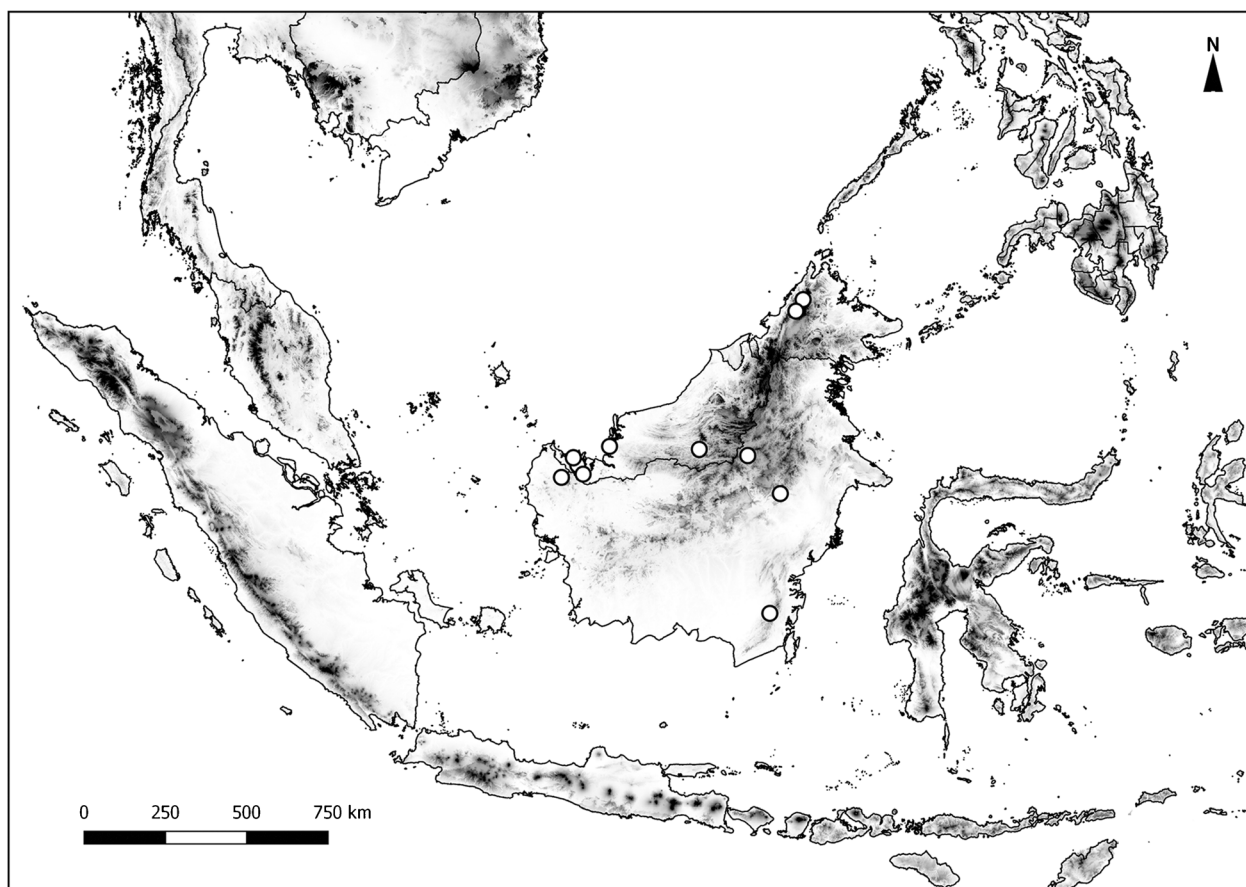


Fig. 7. *Korthalsia cheb*. A inflorescence (Lee S.54592); B ocrea (Van Valkenburg 1206); C leaflets (Van Valkenburg 1206); D fruit (Dransfield et al. 5882).



Map 3. Distribution of *Korthalsia cheb*. Dots are point localities of specimens examined.

green above, glabrous, with caducous, whitish indumentum on undersurface, distal margin conspicuously praemorse, transverse veinlets conspicuous, moderately closely spaced, 1.0–1.5 mm. *Inflorescence* lax, 64.3–150 cm long including c. 19.2 cm peduncle, branched to (1–) 2 orders; prophyll 13.2–15.2 × 1.2–2.0 cm; rachis bracts up to 5.7–7.0 × 2.0–2.7 cm, tightly sheathing, with caducous, dark brown indumentum; primary branches 1–4, 6.5–8.5 cm apart; proximal primary branch 18.0–29.5 cm long, with up to 1–4 rachillae; rachillae 14.5–26.2 cm long and slender including 0.7–4.2 cm visible stalk, 0.7–1.0 cm wide, densely hairy between rachilla bracts, orange-brown tomentose. *Flower* not seen. *Fruit* ovoid, 1.9–2.7 × 1.2–1.9 cm covered in 16–21 vertical rows of reddish-brown scales. *Seed* 1.7 × 1.0 cm; endosperm ruminate. (Figs 1A, 2A, 3A, 4, 8).

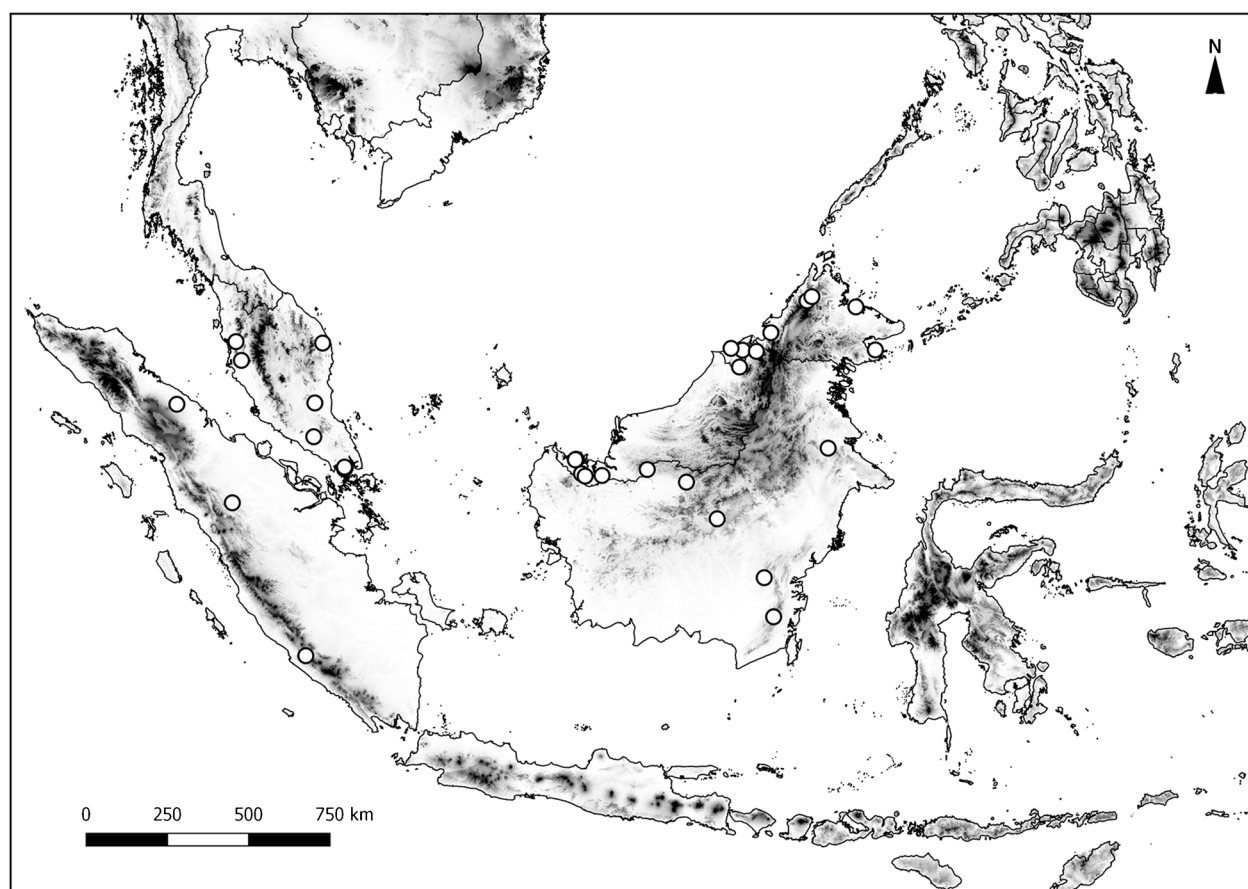
DISTRIBUTION. Peninsular Malaysia, Borneo (Brunei, Kalimantan, Sabah and Sarawak), Singapore, Sumatra (Map 4).

SPECIMENS EXAMINED. **SUMATRA. INDONESIA. SUMATRA UTARA:** Silo Maradja, Asahan, in the vicinity of Taloen Djoring, [3°8'N 99°10'E], Dec. 1927, *Toroes* 64 (K!); **RIAU:** Bukit Suligi, 200 m elev., [0°24'N 100°42'E], Aug. 1986, *Sutisna* 081 (K!); **JAMBI:** Batang

Tebopandak, nearest city Muara Bungo, 300 m elev., Sept. 1993, *Trichon* 796 (K!); **BENGKULU:** Muara Aman, Ketenong, 675 m elev., [3°49'S 102°43'E], 18 Dec. 1984, *Uhaedi* 009 (K!); **SUMATRA SELATAN:** Palembang, *De Vriese* (L). **MALAY PENINSULA. MALAYSIA. JOHOR:** Muar, Ma' Okil Forest Reserve, Cpt. 218, valley bottom, 50 m elev., [4°09'N 103°19'E], 7 June 1977, *Dransfield* 5019 (K!, KEP!). **PAHANG:** Maran, Cehabu, near Gun Tung Kat, N of Sori Jaya, 17 July 1987, *Gianno* 119 (A, BISH, BO, K!, KEP!, KLU, L, LAE, P, PNH, SAN, SAR, SING, TI, TNS, UC, US); Pekan, Ulu Jeram, 76.2 m elev., 2 July 1987, *Gianno* 79 (A, BISH, BO, K!, KEP!, KLU, L, LAE, P, PNH, SAN, SAR, SING, TI, TNS, UC, US); Kuantan, Bukit Ibam, [3°10'N 102°58'E], 30 May 1987, *Gianno* 36 (A, BISH, BO, K!, KEP!, KLU, L, LAE, P, PNH, SAN, SAR, SING, TI, TNS, UC, US). **PERAK:** Taiping, Maxwell's Hill, 975.36 m elev., [4°52'N 100°47'E], 9 March 1924, *Burkill* 12787 (K); Bota, Universiti Teknologi Mara, Bandar Seri Iskandar, [4°21'N 100°57'E], 9 Jan. 2007, *Chan FRI* 49263 (K!, KEP!). **TERENGGANU:** Kemaman, Bukit Kajang, 14 Nov. 1935, *Corner* 30467 (K, SING); Dungun, Jerangau Dalam, [4°49'N 103°11'E], 18 Nov. 2014, *Shahimi* 9 (K!, KEP!). **SINGAPORE:** Herbarium Botanic Gardens, 15 June 1949, *Furtado* 37946



Fig. 8. *Korthalsia echinometra*. A ocrea; B leaflets (Bunker 27); C inflorescence (Dransfield 2828); D fruit (Dransfield 2828).



Map 4. Distribution of *Korthalsia echinometra*. Dots are point localities of specimens examined.

(AA, BH, BO, K!, L, LAE, KEP, PAR, PNH, SAR, SING!); Chau Chu Raug, 10 Dec. 1892, *Ridley* 3521 (K!); Nee Soon jungle, Thomson Road, *bin Rani* 27 (K, SING!); Nee Soon Swamp Forest, [1°24'N 103°48'E], *Rajasegar* 18 (K!); MacRitchie Forest, 39 m elev., [1°21'N 103°48'E], 9 Dec. 2014, *Shahimi* 23 (K!, SING!). **BORNEO. BRUNEI. BELAIT:** along Sungai Ingei, [4°10'N 114°43'E], 5 Jan. 1989, *Wong* s.n. (K!). **TUTONG:** Bukit Ladan Forest Reserve, Compartment 69, [4°38'N 114°48'E], 13 April 1993, *Ibrahim* 15126 (K!); Sungai Liang, Sungai Liang Arboretum Reserve, [4°41'N 114°29'E], *Wong* 143 (K!). **TEMBURONG:** Batu Apoi, Ridge running W of landing place, 250 m elev., [4°36'N 115°11'E], *Simpson* 2365 (K); Amo, Sungai Temburong at Kampung Belalong, ridge W of river, 150 m elev., [4°36'N 115°11'E], 25 June 1989, *Dransfield* 6721 (K!). **INDONESIA. KALIMANTAN UTARA:** Northern part of island Nunukan, NE Borneo (Kalimantan), km 3 from the coast, 6 Nov. 1953, *Meijer* 2054 (K!). **KALIMANTAN BARAT:** Mendalam R., Betung Kerihun National Park, 200 m elev., [0°59'N 113°15'E], 1 Aug. 2001, *Watanabe* 14 (BO, K!); Sanggau, near village of Bedigong, 2 Feb. 1996, *Graefen* 2 (K!). **KALIMANTAN SELATAN:** District Tabalong, Upper Tabalong Area, PT Aya Yayang Indonesia Concession,

Misim, 50 m elev., [1°40'S 115°24'E], 5 Aug. 2000, *Mogea* 7403 (BO, K!, L, NY, WAN); P.T. Yayang Tanjung, 200 m elev., 22 Aug. 1985, *Auggana* 047 (K); Barabai, Pergunungan Meratus, foothills of Gunung Besar, 500 m elev., [2°45'S 115°40'E], 18 Oct. 1972, *Dransfield* 2828 (BH, K!, L). **KALIMANTAN TENGAH:** near Rekut base camp, 250 m elev., [0°2'S 114°6'E], 11 April 1992, *Awmack* 296 (K!). **KALIMANTAN TIMUR:** Berau, RKT 92-93, Inhutani I concession, 250 m elev., 8 Oct. 1991, *Stockdale* 143 (K!); Berau, near km 37 Camp, Inhutani I, 80 m elev., [1°55'N 117°10'E], 9 Aug. 2003, *Watanabe* 60 (K!); between Sinara and Entang Rivers on [floodplain] of Sangatta River, Kutai Reserve, 200 m elev., 31 Oct. 1991, *Stockdale* 87 (K!). **MALAYSIA. SABAH:** Sandakan, Kabili-Sepilok Forest Reserve, [5°50'N 117°56'E], 12 June 1937, *Enggoh* 7432 (K!); Semporna, Mapat Reserve, Timbun Mata Forest Reserve, 1 Aug. 1937, *Puasa* 7404 (K!); Kampung Kauluan, [6°0'N 116°35'E], 9 May 1994, *Sambuling* 169 (K!); Ranau, Kampung Takutan, [6°7'N 116°43'E], 29 March 1995, *Tadong* 179 (K!); Ranau, Kampung Poring, Minintaiiku Forest Reserve, 4 May 1994, *Sambuling* 144 (K!); Kampung Poring, on the hill top, 4 Jan. 1994, *Sambuling* 45 (K!); Kampung Poring, 9 Sept. 1992, *Giking* 22 (K!); Kampung Poring, 10 Feb. 1994, *Sambuling* 82 (K!); Kampung Tensungoi,

[5°7'N 115°35'E], 2 June 1994, *Sambuling* 202 (K!); Mile 55, Sandakan-Telupid, 100 m elev., 26 Oct. 1979, *Dransfield et al.* 5818 (K!, SAF, SAR). **SARAWAK:** Kuching, Gunung Serapi, Kubah National Park, forest trail, 274.32 m elev., [1°36'N 110°12'E], 7 Feb. 1995, *Baker* 509 (K!, KEP!); Kuching, 1st Division, Kampung Semedang, 24th Mile Penrissen Road, 11 Aug. 1985, *Saigol* 15 (K!); Gunung Matang, 1 June 1866, [1°36'N 110°10'E], *Beccari* PB 1935 (FI!); Gunung Matang, [1°36'N 110°10'E], 1 June 1866, *Beccari* PB 1918 (FI!); 1st Division, Kampung Gayu, 250 m elev., [1°13'N 110°21'E], 15 July 1993, *Bunker* 27 (K!); 1st Division, Kampung Kakeng, 200 m elev., [1°9'N 110°27'E], 20 July 1993, *Bunker* OX 39 (K!); Kapit, 7th Division, 8 km Logging Camp, Nanga Mujong, 28 Aug. 1985, *Saigol* 25 (K!); Lubok Antu, 2nd Division, Delok R., on slope in open secondary forest near Nanga Sumpa, 250 m elev., [1°20'N 112°10'E], 5 March 1993, *Christensen* 1211 (K!); Simunjan, 1st/2nd Division Border Gunung Buri, near summit, 700 m elev., [1°10'N 110°55'E], 22 May 1981, *Dransfield et al.* 6115 (K!, L, NY); Baram, on hill behind house, Long Selatong Ulu, 228.6 m elev., 15 July 1977, *Chung* 2768 (K!); Belaga, 3rd Division, Sungai Masoh, rumah Nyaving, Kuala Linau, Ulu Belaga, 200 m elev., 9 Aug. 1975, *Dransfield* 4688 (K!, KEP!, L).

HABITAT. Lowland and hill dipterocarp forest up to 1000 m above sea level.

VERNACULAR NAMES. *Wi wisro* (Iban), *Wee tujah* (Kayan), *Owei lia* (Murut), *Uwai kapot alot* (Kenyah), *Paikat talusuk* (Dayak lawangan), *Rotan keruk* (Iban), *Rotan udang* (Jakun), *Rotan seru* (Iban), *Rotan lia* (Dusun), *Pipit gading* (Dusun), *Wi serok* (Iban), *Rotan semut udang* (Dayak), *Semeii* (Bidayuh).

USES. Cane used to make basket frames, weaving handicrafts and also to tie planks on dugouts to raise the side wall of canoes. Sap can be drunk for fever.

NOTES. *Korthalsia echinometra* is one of the commonest species of the genus *Korthalsia*. It is a very distinctive species, yet from a distance, it can be mistaken for other rattan genera because of its narrow lanceolate leaflets. Its large inflated ocrea with long slender spines and narrowly lanceolate leaflets are diagnostic. The ocreas of *K. echinometra* are reported to be inhabited by ants of the species *Camponotus contractus* (Bequaert & Wheeler 1922) and *Iridomyrmex* species (Chan *et al.* 2012). One of us (WJB) has observed evidence of ants modifying the ocreas of *K. echinometra* by biting fibres in the ocrea wall, which then result in minute slits a few millimetres long opening in the ocrea, presumably altering the microclimate within the ocrea.

4. *Korthalsia furcata* Becc. (Beccari 1918: 120). Type: Indonesia, West Kalimantan, Sungai Kenepai, *Hallier* 2034 (holotype BO; isotype FI!).

Slender, clustering rattan climbing to 20 m. *Stem* with sheaths 4 – 6 mm diam., without sheaths 2 – 3 mm diam.; internodes c. 9 cm. *Leaf* c. 0.6 m long including cirrus and petiole; sheath brown, with caducous, brown-coloured indumentum, sheath armed with scattered abundant brown triangular spines, spines 1 – 3 mm long, c. 1 mm wide; ocrea 20 – 25 × 10 – 11 mm, small, almost rounded and start inflated above the petiole, clasping the stem, tough, brownish, armed with c. 2 mm long tiny triangular spines, ant present; cirrus c. 0.28 m, armed with recurved grapnel spines organised in whorls; petiole c. 2 cm, c. 4 mm wide and c. 2 mm thick at base, flattened adaxially, abaxially rounded, with caducous, indumentum as sheath, sparsely armed with spines; rachis 3.5 – 4.0 cm in length, armed with recurved grapnel spines; usually only one leaflet each side of rachis, regularly arranged, furcate (bilobed), mid-leaf leaflets 33.8 – 36.7 × 4.2 – 4.6 cm, leaflet dull green above, glabrous, caducous, grey-whitish indumentum on undersurface, with inconspicuously praemorse margin, transverse veinlets moderately conspicuous, fine and closely spaced, c. 0.5 mm. *Inflorescence* lax, c. 35 cm long, branched to 2 orders; rachis bracts up to 3.0 – 7.7 × 0.7 – 1.5 cm, splitting, with caducous, dark brown indumentum; primary branches 2, 3.5 – 8.3 cm apart; proximal primary branch 14.3 cm long, with up to 2 rachillae; rachillae 4.7 – 17.2 cm long and slender including 0.6 – 1.2 cm visible stalk, 0.6 – 0.7 cm wide, densely hairy between rachilla bracts. *Flower* not seen. *Fruit* mature fruit not seen. *Seed* not seen (Fig. 9).

DISTRIBUTION. Borneo (1st Division at Sarawak, Malaysia and West Kalimantan, Indonesia) (Map 5).

SPECIMENS EXAMINED. BORNEO. INDONESIA. KALIMANTAN BARAT: Sungai Kenepai, [0°35'N 111°56'E], *Hallier* 2034 (BO, FI!). **MALAYSIA. SARAWAK:** Serian, 1st Division, Sabal Tapang Forest Reserve, Block 14, 350 m elev., [1°0'N 110°51'E], 18 May 1981, *Dransfield et al.* 6074 (B, K!, L, NY); Kuching, Sungai Kopak, Ulu Samunsam, 200 m elev., [1°49'N 106°37'E], 21 Aug. 1998, *Rantai & Lai* 74544 (K!, KEP, L).

HABITAT. In valley bottom in transition between hill dipterocarp forest and Kerangas at 350 m altitude.

VERNACULAR NAME. Not recorded.

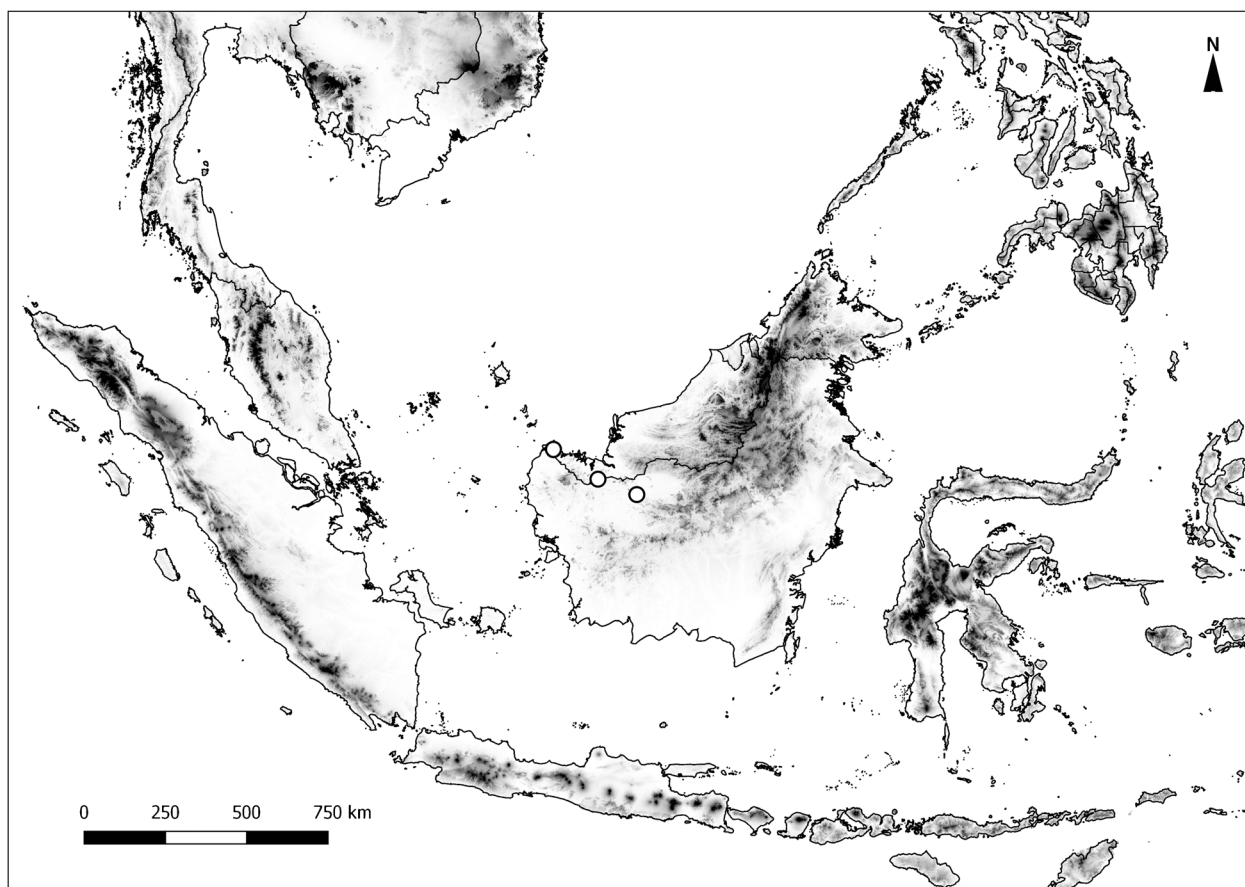
USES. Not recorded.

NOTES. *Korthalsia furcata* is very similar to *K. rostrata* but can be readily distinguished by the leaf, which has only two leaflets that appear forked. It is an extremely rare and poorly known species that is likely to be threatened with extinction.

5. *Korthalsia furtadoana* J.Dransf. (Dransfield 1981: 185). Type: Malaysia, Sabah, 16 Oct. 1979, *Dransfield et al.* JD 5763 (holotype K!; isotype SAN, SAR).



Fig. 9. *Korthalsia furcata*. A leaflets (Dransfield et al. 6074); B inflorescence (Dransfield et al. 6074); C ocrea (Dransfield et al. 6074).



Map 5. Distribution of *Korthalsia furcata*. Dots are point localities of specimens examined.

Slender, clustering rattan climbing to 20 m. *Stem* with sheaths 8 – 11 mm diam., without sheaths 5 – 8 mm diam.; internodes 7 – 12 cm. *Leaf* 0.60 – 0.88 m long including cirrus and petiole; sheath green, with indumentum brown in colour, sheath armed with scattered abundant black triangular spines, spines 1 – 6 mm long, 1 – 2 mm wide; ocrea 25 – 83 × 10 – 15 mm, conspicuous, tightly sheathing above the petiole and then elongate inflated, clasping the stem, tough, brown, armed with 1 – 6 mm long, triangular black spines, numerous ants within the ocrea, entry hole made by ants visible; cirrus 0.3 – 0.7 m, armed with recurved grapnel spines organised in whorls; petiole 25 – 70 mm, 5 – 7 mm wide and 2 – 3 mm thick at base, flattened adaxially, abaxially rounded, with a few spots of brown indumentum, armed with spines as sheath and reflexed grapnel spines; rachis 0.27 – 0.43 m, armed with recurved grapnel spines; 5 – 6 leaflets each side of rachis, regularly arranged, narrowly rhomboid, mid-leaf leaflets 9.0 – 19.7 × 4.4 – 6.6 cm, leaflet dull to dark green above, glabrous, lacking indumentum on undersurface, with inconspicuously praemorse margin, transverse veinlets conspicuous, fine and closely spaced, c. 0.5 mm. *Inflorescence* lax, 26.5 – 100 cm long including c. 10 cm peduncle,

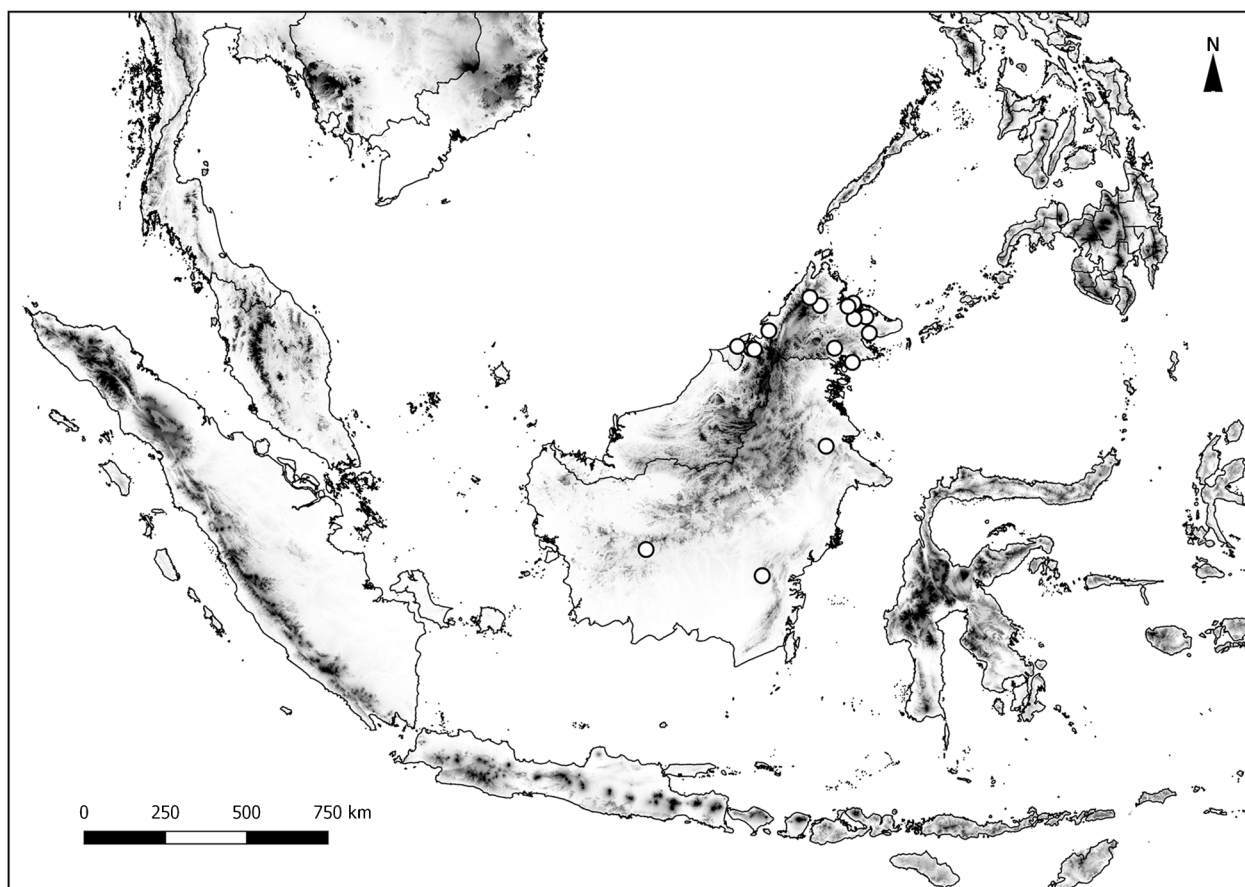
branched to 2 orders; prophyll 1.5 – 6.5 × 0.5 – 0.7 cm; rachis bract up to 3.5 – 5.9 × 1.3 – 3.3 cm, tightly sheathing and splitting, caducous, brown indumentum with several tiny spines; primary branches 1 – 2, 9.5 – 13.5 cm apart; proximal primary branch 13.5 – 19.5 cm long, with up to 1 – 3 rachillae; rachillae 12.0 – 19.8 cm long and congested, stalk not visible, 0.7 – 1.4 cm wide, densely hairy between rachilla bracts. *Flower* 8 × 4 mm in the bud. *Fruit* ovoid, 1.3 – 2.2 × 0.8 – 1.2 cm covered in 15 – 23 vertical rows of yellow-brownish scales. *Seed* 1.2 × 0.8 cm; endosperm ruminant (Fig. 10).

DISTRIBUTION. Borneo (Brunei, Sabah, Central, East and South Kalimantan) (Map 6).

SPECIMENS EXAMINED. BORNEO. BRUNEI. TEMBURONG: Amo, beside the Belalong R., [4°37'N 115°6'E], Wong 1326 (K!); Batu Apoi, Bukit Belitun, Sungai Sinupoi, S of village, 40 m elev., [4°36'N 115°11'E], 21 Jan. 1994, *Dransfield* 7477 (K!). **TUTONG:** Lamunin, Compartment 1, 30 m elev., [4°41'N 114°43'E], Nov. 1990, *Dransfield et al.* 6875 (K!). **INDONESIA. KALIMANTAN SELATAN:** Tabaling, Upper Tabalong Area, PT Aya Yayang Indonesia Concession, Kebun Bibit, km 54, Sungai Papun, 200 m elev., 6 Aug. 2000,



Fig. 10. *Korthalsia furtadoana*. A leaflets (Howroyd SAN29366); B ocrea (Howroyd SAN29366); C inflorescence (Howroyd SAN29366); D fruit (Howroyd SAN29366).



Map 6. Distribution of *Korthalsia furtadoana*. Dots are point localities of specimens examined.

Mogea 7431 (BO, K!, L, NY, WAN); Tabalong, Upper Tabalong Area, PT Aya Yayang Indonesia Concession, cutting block 1999/2000 near km 54 Kebun Bibit, 400 m elev., 12 Aug. 2000, *Mogea* 7436 (BO, K!, L, NY, WAN); Upper Tabalong Area, PT Aya Yayang Indonesia Concession, Misim, 50 m elev., [1°40'S 115°24'E], 5 Aug. 2000, *Mogea* 7408 (BO, K!, L, NY, WAN); PT Yayang Tanjung, 20 Aug. 1985, *Anggana* 039 (K). **KALIMANTAN TENGAH:** Bukit Raya, [0°56'S 112°11'E], *Leighton* 376 (K). **KALIMANTAN TIMUR:** Berau, near km 37 Camp, Inhutani I, 80 m elev., [1°55'N 117°10'E], 9 Aug. 2003, *Watanabe* 59 (K!, BO); 7 km from Eheng (village), Barong Tongkok (district) near Kelian, upper Mahakan, 10 Nov. 1991, *Stockdale* 101 (K!); Lingau, 2 km from Prampus, P.T. KEM cecession near Kelian, upper Mahakan R., 11 Nov. 1991, *Stockdale* 104 (K!); near Sangatta R., Kutai Reserve, halfway between "Prevab" camp and "Mentoko" camp, 20 m elev., 30 Oct. 1991, *Stockdale* 78 (K!); Mentoko Camp, Kutai Reserve, 50 m elev., 31 Oct. 1991, *Stockdale* 85 (K!). **MALAYSIA. SABAH:** Kalabakan, Hap Seng logged area, km 12, 12 June 1982, *Krispinus* 94884 (K); Kota Kinabatangan, Hutan Simpan Pin-Supu, 80 m elev., [5°27'N 117°56'E], 2 April 1992, *Dewol* SAN 132477 (K!,

SAN); Lahad Datu, Forest Distr. Lahad Datu, [5°2'N 118°21'E], 5 Nov. 1949, *Cuadra* 2498 (K!); Lahad Datu, Block 43 Bagahak, 4 April 1962, *Howroyd* SAN 29366 (K!); Lahad Datu, Cpt. 54 Bakapit, Kennedy Bay, 457.2 m elev., June 1962, *Burgess* SAN 30782 (K!); Nabawan, Mile 2½ Rahsna Road, 19 Jan. 1978, *Abas* SAN 85854 (K!, L, SAR); Pinangah, Ulu Sg. Melikop, 30 Aug. 1984, *Leopold* SAN 64584 (K!); Ranau, Ulu Tungud Forest Reserve, Gunung Monkobo Expedition, 471 m elev., [5°49'N 117°0'E], 25 July 2005, *Saw* SAN 146691 (K!, KEP!, L, SAN, SAR); Ranau, Kampung Poring, [6°2'N 116°42'E], 11 Feb. 1994, *Sambuling* 93 (K!); Sandakan, Ulu Dusun Agriculture station, [5°47'N 117°46'E], 16 Oct. 1979, *Dransfield et al.* JD 5763 (K!, SAN, SAR); Sandakan, Sungai Menenggul, [5°30'N 118°16'E], 27 Feb. 1985, *Amin* SAN 68050 (K!, KEP!); Sandakan, Sepilok Forest Reserve, Forest Distr. Elopura, [5°52'N 117°55'E], 24 Sept. 1949, *Kadir* 2643 (K!, KEP!); Sandakan, Sepilok Forest Reserve, 50 m elev., [5°52'N 117°55'E], 28 Feb. 1995, *Baker* 553 (K!); Sandakan, Kabili-Sepilok Forest Reserve, [5°50'N 117°56'E], 25 July 1937, *Matusop* 7427 (K!); Sandakan, Ulu Dusun Agriculture station, 7 m elev., 16 Sept. 1979, *Dransfield et al.* 5763

(K!, L, SAF, SAR); Sandakan, Subak camp, Jesselton Distr., 19 Dec. 1962, *Madani* SAN 33215 (K!); Tawau, St Lucia, Rangu Mile 10 3/4, state forest, 16 Sept. 1949, *Cuadra* 2377 (KEP); Tawau, Luasong Forest Reserve, logging area, [4°38'N 117°24'E], 16 Aug. 1977, *Fedilis* SAN 87333 (K!, KEP!, L, SAR, SING!); Tawau, mile 10 ó State Forest, Forest Distr. St. Lucia, 16 Sept. 1949, *Lenedia* 2377 (K!); Tawau, Elphinstone Province, [4°14'N 117°53'E], Oct. 1922, *Elmer* 20476 (K!); Tenom, Paling-paling Hills, Lagud, 300 m elev., 4 Sept. 1979, *Dransfield et al.* 5591 (K!, L, SAF, SAR); Danum Valley, Ulu Segama, plot 2, W trail from field station, 150 m elev., 9 March 1987, *Argent* 291987 (E!, K!); BetoTan, 15.24 m elev., 16 May 1933, *Castro* 3201 (K); Kampung Wolit, ½ km from house to E, 29 Aug. 1997, *Jinuan* 24 (K); Ulu Segama, W trail, 200 m elev., 16 Feb. 1986, *Dransfield* 6260 (K); Kampung Tensungoi, [5°7'N 115°35'E], 2 June 1994, *Sambuling* 198 (K!).

HABITAT. Lowland dipterocarp forest.

VERNACULAR NAME. Not recorded.

USES. Not recorded.

NOTES. See notes under *Korthalsia rostrata* for discussion of this species. *Korthalsia furtadoana* ocreas are inhabited by ants of the genera *Camponotus* and *Crematogaster* (Edwards *et al.* 2010).

6. *Korthalsia hispida* Becc. (Beccari 1884: 71). Type: Indonesia, Sumatra, 1 Aug. 1878, *Beccari* PS 643 (holotype FI!: isotype K!).

Moderately robust, clustering rattan climbing to 20 m. *Stem* with sheaths 11 – 25 mm diam., without sheaths 8 – 10 mm diam.; internodes 10 – 20 cm. *Leaf* 1.15 – 2.0 m long including cirrus and petiole; sheath bright green, with caducous, brown-coloured indumentum, sheath armed with scattered abundant, black, needle-like spines, spine 2 – 30 mm long, c. 1 mm wide; ocrea 18.5 – 30.0 × 3.0 – 4.5 cm, conspicuous, diverging from the angle at stem just above the petiole, the margins tending to inroll, papery, brown, armed with 3 – 30 mm long black spines and abundant chocolate spicules, abundant black fierce and very noise ants nested within the ocrea; cirrus 0.5 – 1.0 m, armed with recurved grapnel spines organised in whorls; petiole 10.0 – 35.0 cm, 10 – 20 mm wide and 3 – 5 mm thick at base, flattened adaxially, abaxially rounded, with brown indumentum, sparsely armed with fine spines as sheath; rachis 0.30 – 1.07 m, armed with recurved grapnel spines; 5 – 8 leaflets each side of rachis, regularly arranged, rhomboid, mid-leaf leaflets 15.0 – 19.6 × 5.0 – 8.6 cm, leaflet dull to light green above, glabrous, with caducous, whitish indumentum on undersurface, distal margin conspicuously praemorse, transverse veinlets moderately conspicuous and moderately spaced, 1.0 – 1.5 mm. *Inflorescence* lax to congested, 30.0 – 50.2 cm long including c. 45 mm peduncle, branched to (1 –) 2 orders;

prophyll 4.5 × 1.0 cm, with caducous, dark brown indumentum with scattered tiny spines; rachis bracts up to 8.3 – 9.5 × 2.6 – 3.4 cm, conspicuous, inflated and splitting, with caducous, dark brown indumentum and densely covered with chocolate scales and black spicules; primary branches 1 – 4, 4.0 – 6.6 cm apart; proximal primary branch 17.0 – 27.5 cm long, with up to 1 – 3 rachillae; rachillae 11.5 – 22.3 cm long and slender, stalk not visible, 1.0 – 1.8 cm wide, lacking hairy between rachilla bracts. *Flower* 8 – 8.1 × 3.3 – 3.7 mm in the bud. *Fruit* round to oblong, 1.8 – 2.3 × 0.9 – 1.6 cm covered in 15 – 18 vertical rows of reddish-brown scales. *Seed* 1.1 × 0.8 cm; endosperm homogeneous (Fig. 11).

DISTRIBUTION. Malay Peninsula, Borneo (Brunei, Sabah, Sarawak, East and South Kalimantan), Sumatra (Map 7).

SPECIMENS EXAMINED. SUMATRA. INDONESIA. SUMATRA

BARAT: Padang, Ayer manior (Ajer mantjoer), [0°57'S 100°25'E], Aug. 1878, *Beccari* 643 (K!). **MALAY**

PENINSULA. MALAYSIA. JOHOR: Bekuk, Hutan Lipur Batang, 90 m elev., [2°20'N 103°9'E], 24 Nov. 2014, *Shahimi* 11 (K!, KEP!); Kota Tinggi, Panti Forest Reserve, 10 m elev., 10 June 1977, *Dransfield* 5035 (K!); Kota Tinggi, Gunong Panti, East Forest Reserve, 20 m elev., [1°50'N 103°54'E], 7 Jan. 1973, *Dransfield* 3037 (BH, BO, BRI, CAL, CANB, G, K!, KEP, L, LAE, MAN, NSW, NY, PAR, SAN, SAR, SING!, US); Labis, Labis Forest Reserve, Ulu Endau, Gunung Janing, valley bottom, 100 m elev., [2°10'N 103°22'E], 16 June 1977, *Dransfield* 5090 (K!). **PAHANG:** Kuantan, Galing Forest Reserve, 20 m elev., [3°52'N 103°19'E], 11 Aug. 1977, *Dransfield* 5227 (K!). **BORNEO. BRUNEI.**

BELAIT: Labi, Teraja Longhouse, [4°23'N 114°26'E], *Wong & Dransfield* 540 (K!, SING!). **TEMBURONG:** Amo, Belalong R. bank near Field Studies Centre, E side, 300 m elev., [4°33'N 115°9'E], 6 Sept. 1991, *Stockdale* 31 (K!); Batu Apoi, Kerangan Batu Semawat, WNW of village, 30 m elev., [4°36'N 115°11'E], *Dransfield et al.* 7494 (K!); Batu Apoi National Park, Kuala Belalong Field Centre Temburong R., 50 m elev., [4°35'N 115°10'E], 15 Feb. 1995, *Baker* 531 (BRUN, K!, UBD); South Temburong, above Kuala Belalong, 75 m elev., [4°30'N 15°10'E], 21 Feb. 1991, *Argent et al.* 9168 (K!).

TUTONG: Lamunin, between the rivers Batas and Tutong, [4°41'N 114°43'E], *Wong* 1663 (K!). **INDONESIA. KALIMANTAN SELATAN:** Tabalong, upper Tabalong area, PT Aya Yayang Indonesia Concession, km 69, 250 m elev., 7 Aug. 2000, *Mogea* 7412 (BO, K!, L, NY, WAN); Tabalong, Upper Tabalong Area, PY Aya Yayang Indonesia Concession, Misim, 50 m elev., [1°40'S 115°24'E], 6 Aug. 2000, *Mogea* 7410 (BO, K!, L, NY, WAN); P.T. Yayang Tanjung, 100 m elev., 22 Aug. 1985, *Anggana* 048 (K). **KALIMANTAN TIMUR:** Bordering Talib's Farm, Lingon, 2 km from Prampus, PT KEM concession, Kelian, upper Mohakan R., 11

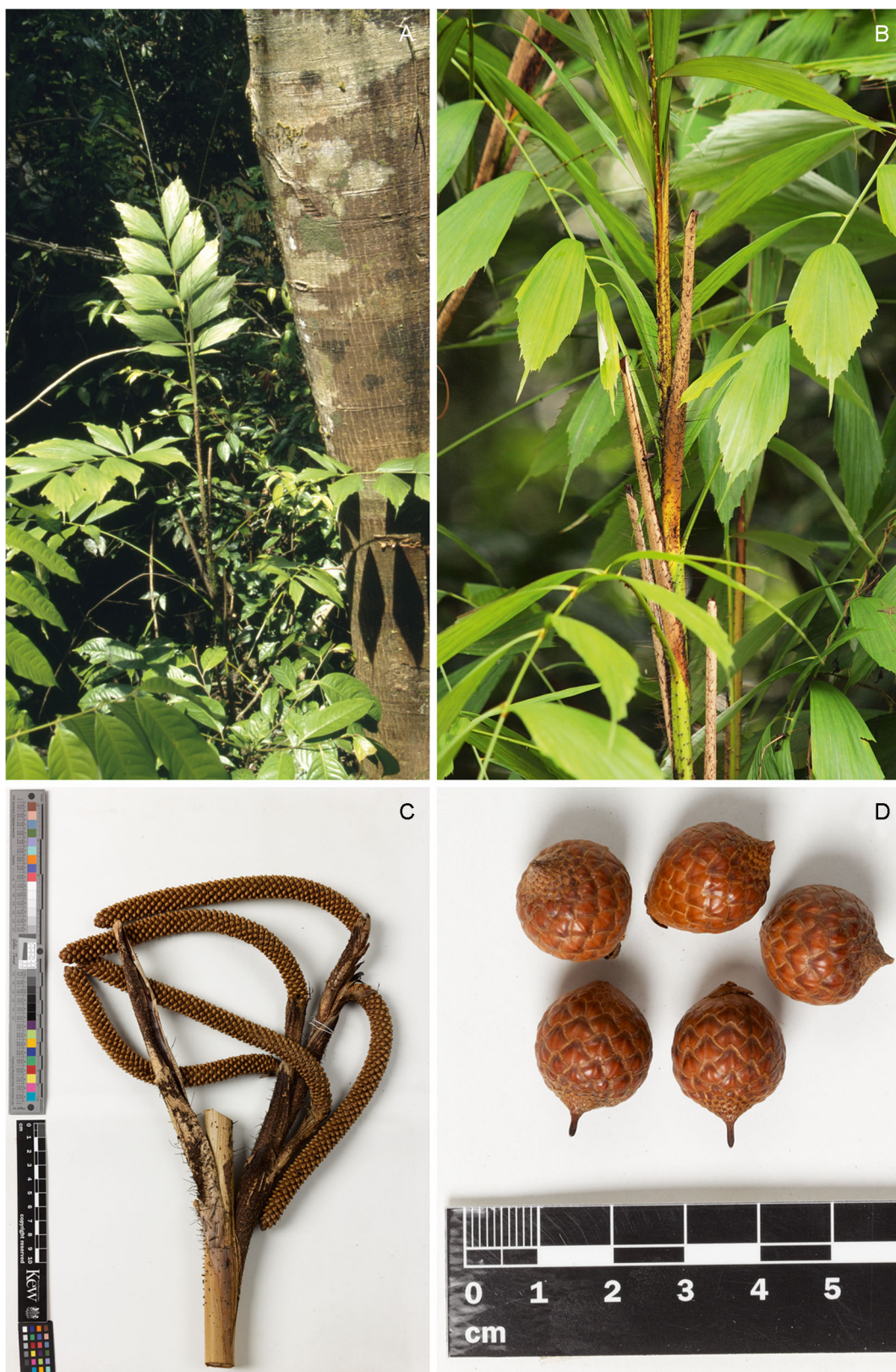
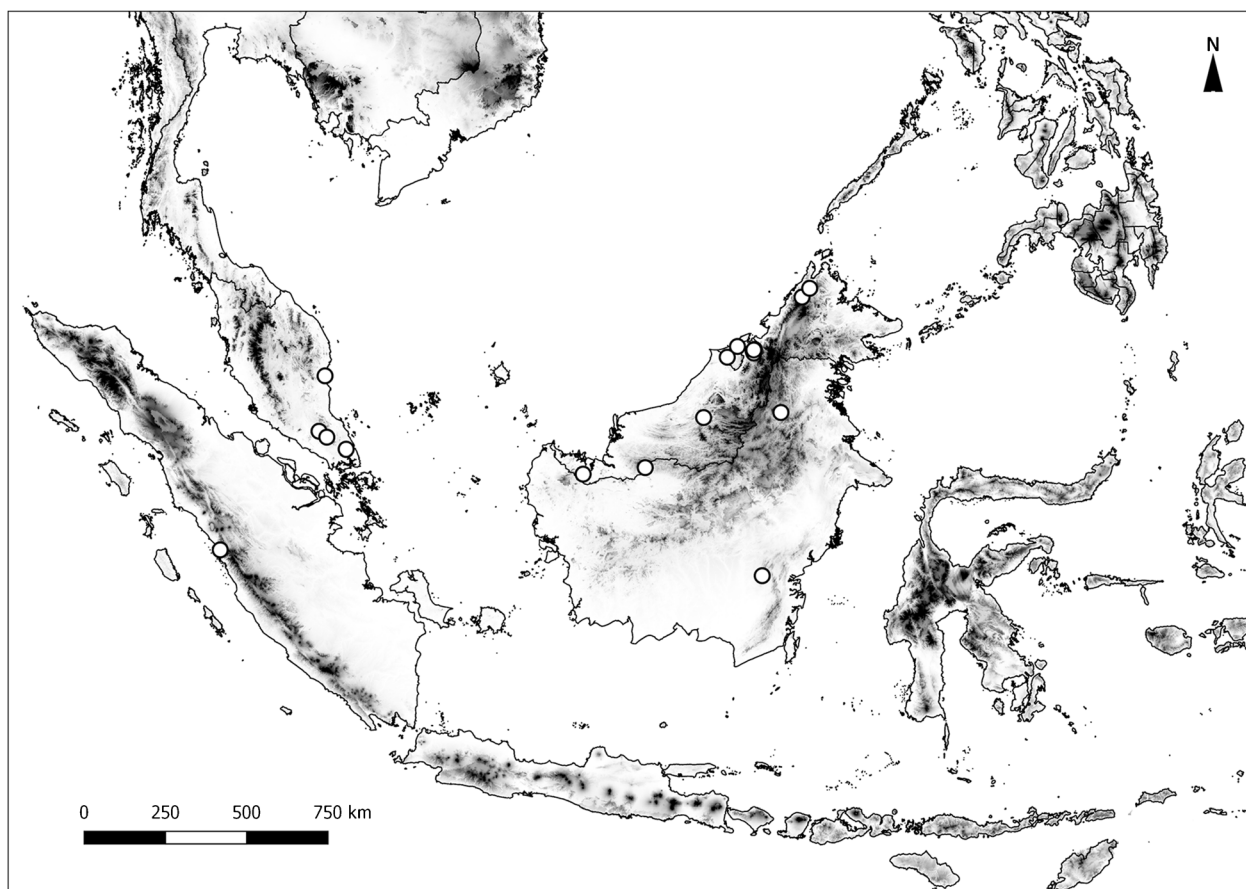


Fig. 11. *Korthalsia hispida*. A habit; B ocrea; C inflorescence (Dransfield et al. 7494); D fruit (Argent & Mitchell 9168).



Map 7. Distribution of *Korthalsia hispida*. Dots are point localities of specimens examined.

Nov. 1991, *Stockdale* 106 (K!); Surroundings WWF basecamp, Kayan Mentarang Reserve, 400 m elev., [2°51'N 115°55'E], 24 Nov. 1991, *van Valkenburg* 1063 (K!); Berau, RKT 92-93, Inhutani I Concession, 250 m elev., 8 Dec. 1991, *Stockdale* 142 (K!). **MALAYSIA.** **SABAH:** Telupid, c. 8 miles, Entelebun-Menanam, 150 m elev., 24 Sept. 1979, *Dransfield et al.* 5803 (K!, SAF, SAR); Tenom, hills above Kampung Baru Jumpa, 700 m elev., 5 Sept. 1979, *Dransfield et al.* 5598 (K!, KEP!, SAF, SAR); Kampung Kiau Nuluh, [6°2'N 116°29'E], 19 Sept. 1992, *Duaneh* 118 (K); Kampung Sorinsim, [6°17'N 116°42'E], 17 March 1993, *Sibil* 162 (K!). **SARAWAK:** Baram, 4th Division Around Long Selatong Lepo Ga', on hill behind house, banks of Benuon R., 400 m elev., 19 April 1980, *Chin* 3008 (K!); Belaga, 3rd Division, Sungai Masoh, rumah Nyaving, Kuala Linau, Ulu Belaga, 200 m elev., [2°42'N 113°46'E], 10 Aug. 1975, *Dransfield et al.* 4705 (BH, K!, KEP!, L, SING!); Kapit, upper Rejang R., *Clemens* 22085 (K!); Kuching, 1st Division, Kampung Kakeng, 200 m elev., [1°9'N 110°27'E], 20 July 1993, *Bunker* 36 (K!); Tawau, Elphinstone Province, British North Borneo, Oct. 1922, *Elmer* 21553 (K!); Lubok Antu, 2nd Division,

Delok R., on steep slope in secondary forest near Nanga Sumpa, 200 m elev., [1°20'N 112°10'E], 31 May 1993, *Christensen* 1188 (K!).

HABITAT. Along steep-sided river valleys in lowland and hill dipterocarp forest at altitudes up to 900 m above sea level.

VERNACULAR NAMES. *Rotan semut* (Iban), *Paikat ayah pipit* (Dayak Lawangan), *Wi asas* (Iban), *Wi semut* (Iban), *Lesat* (Lundaya), *Uwai saar* (Kenyah), *Uei sanam* (Kenyah), *Laku sepuru* (Punan), *Ohot* (Dayak Tunjung).

USES. Fibre for the plaiting of baskets, craft and binding constructions.

NOTES. *Korthalsia hispida* and *K. robusta* are the only two myrmecophilous species in *Korthalsia* with ocreas that do not clasp the stem, but diverge at an acute angle just above the petiole. These two species are the noisy rattans. The ocreas of *K. hispida* are inhabited by ants of the genus *Camponotus* (Mattes *et al.* 1998). The ants make a rhythmic, hissing noise by banging their mandibles against the ocrea when the plant is disturbed. *Korthalsia hispida* can be distinguished from *K. robusta* by the presence of black spicules on the ocrea and sheaths.

7. *Korthalsia robusta* Blume (1843: 170). Type: Indonesia, Sumatra, *Praetorius* s.n. (holotype L: isotype K!, L!).

Korthalsia squarrosa Becc. (Beccari 1909: 620). Type: Philippines, Palawan, Curran 4155 (holotype FI; isotype K!).

Korthalsia macrocarpa Becc. (Beccari 1918: 149). Type: Indonesia, Borneo, H. Winkler 2777 (holotype FI).

Robust, clustering rattan climbing to 40 m. *Stem* with sheaths 20 – 35 mm diam., without sheaths 14 – 20 mm diam.; internodes 24 – 25 cm. *Leaf* 1.5 – 3.0 m long including cirrus and petiole; sheath bright green to green, with abundant dark brown to brown-black floccose, sparsely armed with scattered black, triangular spines, spines 2 – 30 mm long, 1 – 2 mm wide; ocrea 16.0 – 41.0 × 3.0 – 7.0 cm, conspicuous, diverging from the angle at stem just above the petiole, the margins tending to inroll, papery, brown in colour, armed with abundant 2 – 30 mm long dark brown spines, black ants usually abundant and very noisy; cirrus 0.50 – 1.75 m, armed with recurved grapnel spines organised in whorls; petiole 10 – 35 cm, 12 – 30 mm wide and 4 – 6 mm thick at base, flattened adaxially, abaxially rounded, with slightly grey indumentum, sparsely armed with spines as sheath; rachis 0.65 – 1.35 m, armed with recurved grapnel spines; 6 – 10 leaflets each side of rachis, regularly arranged, rhomboid to broadly rhomboid, mid-leaf leaflets 20.2 – 27.8 × 4.2 – 13.8 cm, leaflet dull green to dark green above, glabrous, with grey-whitish indumentum under surface, distal margin conspicuously praemorse, transverse veinlets conspicuous, fine and closely spaced c. 0.5 mm. *Inflorescence* congested, 34.9 – 51.0 cm long including 3.5 – 15.0 cm peduncle, branched to 2 orders; prophyll 2.5 – 8.0 × 2.2 – 3.7 cm, with caducous, brown indumentum; rachis bracts up to 12.3 – 16.2 × 4.7 – 8.0 cm, conspicuous, inflated, with caducous, dark brown indumentum and black spicules; primary branches 3, 3.0 – 4.5 cm apart; proximal primary branch 16.0 – 17.0 cm long, with up to 2 rachillae; rachillae 13.0 – 16.0 cm long and slender, stalk not visible, 1.2 – 2.0 cm wide, lacking hairs between rachilla bracts. *Flower* 8.4 – 11.0 × 3.4 – 5.0 mm in the bud. *Fruit* round to oblong, 1.8 – 2.3 × 0.9 – 1.6 cm covered in 16 – 18 vertical rows of mid-brown scales with straw-coloured margins. *Seed* 1.8 × 1.0 cm; endosperm homogeneous (Figs 1C, 2D, 3D, 12).

DISTRIBUTION. Borneo (Sabah, Sarawak, Central, East and South Kalimantan), Philippines (Palawan), Sumatra (Map 8).

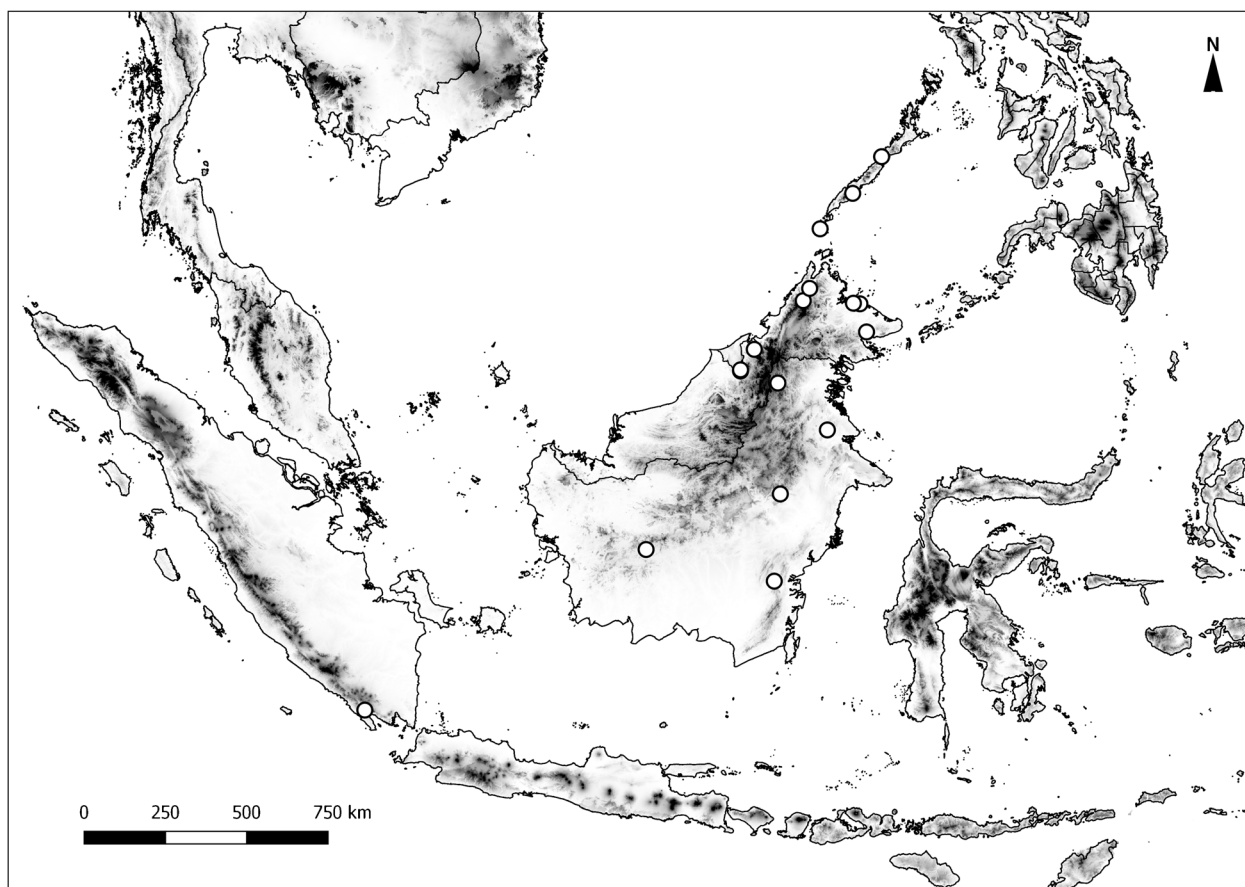
SPECIMENS EXAMINED. SUMATRA. INDONESIA. LAMPUNG: NW of Kota Agung, 350 m elev., [5°23'S 104°25'E], 9 May 1968, *Jacobs* 8295 (K!); *Praetorius* s.n. (K!, L!).

BORNEO. BRUNEI. TEMBURONG: Batu Apoi National Park, Kuala Belalong Field Centre Jalan Tengah, path to Bukit Belalong, 1 km from field centre, 300 m elev.,

[4°35'N 115°10'E], 16 Feb. 1995, *Baker* 534 (BRUN, K!, UBD). **INDONESIA. KALIMANTAN TENGAH:** Bukit Raya, [0°56'S 112°11'E], *Leighton* 947 (K!). **KALIMANTAN TIMUR:** Berau, near km 37 Camp, Inhutani I, 30 m elev., [2°22'N 117°12'E], 18 Aug. 2002, *Watanabe* 44 (BO, K!); Halfway between Prevab and Mentoko Camps, Kutai Reserve, floodplain of Sangatta R., 20 m elev., 30 Oct. 1991, *Stockdale et al.* 80 (K); Tabang, Gunung Mendam, KTI, 400 m elev., [0°36'N 115°54'E], 16 Jan. 1979, *Mogea* 1629 (K!, KYO); Ma Ancalong, Ma Lun, Sungai Kelinjau, 4 Oct. 1980, *Mogea* 2708 (K!). **KALIMANTAN SELATAN:** Sungai Rusi near Mt Sarempaka, 450 m elev., [1°49'S 115°44'E], 4 Nov. 1972, *de Vogel* 2073 (K!); Datar Alai, Pegunungan Meratus Barabai, 350 m elev., 26 Oct. 1972, *Dransfield* 2967 (BH, K!, L). **MALAYSIA. SABAH:** Lahad Datu, Masuri, Ulu Segama, [5°5'N 118°17'E], 20 Nov. 1949, *Cuadra* 248 (K!, KEP!); Ranau, Kampung Bundu Tuhan, Kinatongan, [5°57'N 116°32'E], 7 Sept. 1994, *Soibeh* 828 (K!); Ranau, Poring, near hot springs, 700 m elev., 29 Aug. 1979, *Dransfield et al.* 5563 (K!, KEP!, SAP, SAR); Ranau, Kampung Poring, next to Mamut Copper Mine, 3 May 1994, *Sambuling* 133 (K!); Sandakan, Elopura, Mile 15 state forest, [5°41'N 118°6'E], 24 March 1949, *Cuadra* 2226 (K!, KEP!); Sandakan, Elopura, Sapagaya R., 21 May 1949, *Cuadra* 2275 (K!, KEP!); Sandakan, Sepilok Forest Reserve, 50 m elev., [5°52'N 117°55'E], 28 Feb. 1995, *Baker et al.* 552 (K!); Sandakan, Virgin Jungle Reserve, Mile 42 Segaliud-Lokan Forest Reserve, 50 m elev., 18 Oct. 1979, *Dransfield et al.* 5772 (K!, SAF, SAR); Tambunan, Kampung Mansaralong mile 56 ½, 11 July 1978, *Abas* SAN 85923 (K!); Kinabatangan Besar, Kori, timber camp, [5°38'N 118°36'E], 2 Nov. 1948, *Cuadra* 2158 (K!, KEP!); Kota Marudu Distr., Kampung Sorinsim, [6°17'N 116°42'E], 27 April 1995, *Bakia* 339 (K!). **SARAWAK:** Baram, Sungai Tutoh, 45.72 m elev., [4°0'N 114°48'E], 11 Feb. 1966, *Wee-Lek* 1086 (K!); Kapit, 7th Division, 8 km Logging Camp, Nanga Mujong, 28 Aug. 1985, *Saigol* 33 (K!); Miri, Gunung Mulu National Park, 4th Division, on banks of Sungai Melinau near base camp, 30 m elev., 3 Oct. 1977, *Dransfield* 5262 (K!, NY); Miri, Gunung Mulu National Park, 35 m elev., [4°2'N 114°48'E], 14 Sept. 2015, *Shahimi* 26 (K!, KEP!); 4th Division, Kelabit Highlands on slope in secondary forest near Ramudu, 900 m elev., [3°40'N 115°50'E], 6 Oct. 1993, *Christensen* 185 (K!). **PHILIPPINES. PALAWAN:** Balabac Island, [7°56'N 117°0'E], 16 Oct. 1906, *Merrill* 5384 (K!); Kampo 1, 5 March 1984, *Madulid* 1010 (K); St. Paul's Bay National Park, Lion Cave, 15 m, 7 May 1984, *Dransfield* 6177 (K!); Pulot III, N of Brooke's Point, 100 m elev., [8°55'N 117°54'E], 22 May 1984, *Dransfield* 6206 (K!); Puerto Princesa, Bagumbayan, 22.86 m elev., 18 Nov. 1983, *Baja-Lapis* 072 (K!); Puerto Princesa, on road between Puerto Princesa



Fig. 12. *Korthalsia robusta*. A habit; B ocrea; C inflorescence (Dransfield 5262); D fruit (Dransfield 5262).



Map 8. Distribution of *Korthalsia robusta*. Dots are point localities of specimens examined.

and Palawan Consolidated Mining Corporation's Concession, 100 m elev., [9°56'N 118°42'E], 11 April 1979, *Dransfield* 5492 (K!); *Curran* 4155 (FI, K!).

HABITAT. Lowland dipterocarp forest.

VERNACULAR NAMES. *Oros* (Kutai dialect), *Rotan lasas* (Kadazan), *Wi semut* (Iban), *Wae asa* (Kelabit language), *Wae perah* (Penan), *Ayas* (Pasir language).

USES. Stem used for tying and weaving of baskets, shoots edible, handicraft and construction.

NOTES. *Korthalsia robusta* is similar to *K. hispida* but can be easily distinguished from *K. hispida* by the absence of black spicules on the sheaths, ocreas, and bracts, and by the very congested inflorescences. *Korthalsia robusta* is a noisy rattan and inhabited by ants of the genus *Camponotus* (Mattes *et al.* 1998).

8. *Korthalsia rostrata* Blume (1843: 168). *Ceratolobus rostratus* (Blume) Becc. (Beccari 1918: 11). Type: Indonesia, Borneo, Sungai Dusun, *Muller* s.n. (holotype L!).

Korthalsia scaphigera Mart. (Martius 1845: 211).

Calamosagus scaphiger (Mart.) Griff. (Griffith 1850: 30). Type: Malaysia, Malacca, *Griffith* s.n. (holotype BR; isotype K!).

Korthalsia lobbiana H.Wendl. (Wendland 1859: 174).

Type: Malaysia, Sarawak, *Lobb* 106 (holotype K!).

Korthalsia machadonis Ridl. (Ridley 1907: 216). Type: Malaysia, Perak, Kamuning. Type not found (Furtado 1951).

Slender, clustering rattan climbing to 20 m. *Stem* with sheaths 5 – 15 mm diam., without sheaths 4 – 6 mm diam.; internodes 10 – 12 cm. *Leaf* 0.4 – 1.1 m long including cirrus and petiole; sheath green, with dark brown to black indumentum, sheath armed with scattered tiny abundant yellow-brown to black triangular spines, spines 1 – 4 mm long, 1 – 2 mm wide; ocrea 25 – 50 × 10 – 30 mm, conspicuous, almost rounded and inflated above the petiole, tough, pale brown to light brown in colour, armed with 2 – 5 mm long, tiny triangular brown to dark brown spines, ants abundant within the ocrea; cirrus 0.30 – 1.25 m, armed with recurved grapnel spines organised in whorls; petiole 2 – 18 cm, 5 – 19 mm wide and 2 – 3 mm thick at base, flattened adaxially, abaxially rounded, with caducous brown indumentum, sparsely armed with spines as sheath; rachis 0.25 – 1.45 m, armed with recurved grapnel spines; 4 – 6 leaflets each side of rachis, regularly arranged, broadly rhomboid,

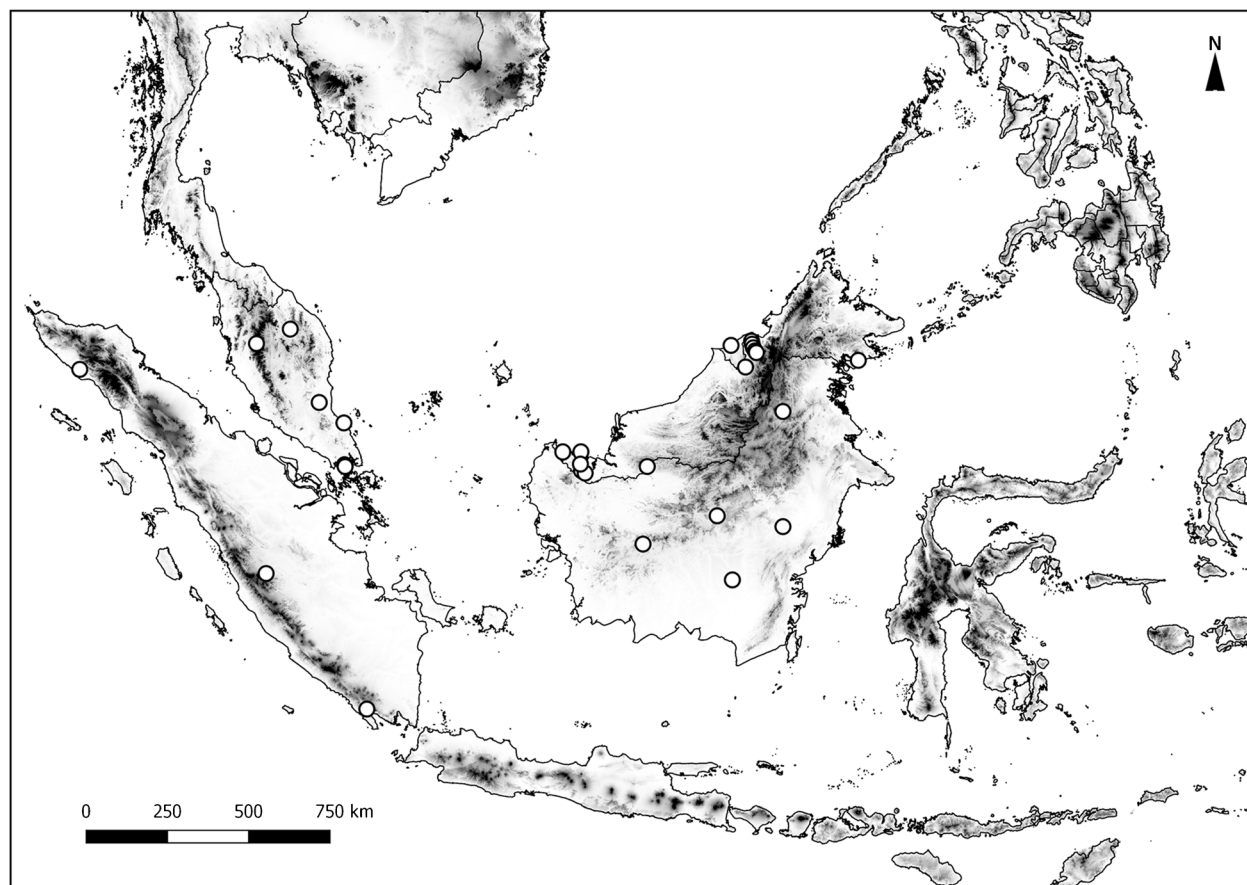


Fig. 13. *Korthalsia rostrata*. A habit; B inflorescence (Church et al. 1302); C ocrea (Dransfield et al. 6085); D fruit (Laumonier TFB 1155).

mid-leaf leaflets $13.5 - 20.5 \times 5.0 - 6.5$ cm, sometimes (rarely) the leaflet narrowly lanceolate, to $21.5 - 30.8 \times 1.5 - 2.8$ cm, leaflet dark green above, glabrous, with caducous, chalky-white indumentum on undersurface, distal margin conspicuously praemorse, transverse veinlets conspicuous, moderately closely spaced, $1.0 - 1.5$ mm. *Inflorescence* lax, $35.2 - 77.5$ cm long including $8.7 - 9.0$ cm peduncle, branched to 2 orders; prophyll $3.5 - 6.0 \times 0.7 - 0.8$ cm, with caducous, brown indumentum; rachis bracts up to $4.5 - 8.7 \times 0.9 - 3.3$ cm, tightly sheathing, splitting, with caducous, brown indumentum with several tiny spines; primary branches 2 – 4, $4.1 - 11.2$ cm apart; proximal primary branch $14.7 - 19.0$ cm long, with up to 2 – 4 rachillae; rachillae $12.7 - 18.6$ cm long and slender, including $0.7 - 1.7$ cm visible stalk, $0.5 - 0.7$ cm wide, variously hairy between rachilla bracts. *Flower* $5.0 - 5.1 \times 2.0 - 2.2$ mm in the bud. *Fruit* $2.4 - 2.5 \times 1.6 - 1.7$ cm covered in 15 – 19 vertical rows of orange-brown scales. *Seed* $1.1 - 1.6 \times 0.7 - 1.0$ cm, endosperm ruminant (Figs 1B, 2C, 3C, 13).

DISTRIBUTION. Malay Peninsula, Borneo (Brunei, Sabah, Sarawak, Central, East and West Kalimantan), Singapore, Sumatra (Map 9).

SPECIMENS EXAMINED. SUMATRA. INDONESIA. ACEH: Aceh Selatan, collected on Gunung Simpang Kiri, 23 Oct. 1997, *Sangaji & Barrow* 11 (K!); Aceh Selatan, Kampong Lamee, 72.85 m elev., $[4^{\circ}1'N\ 96^{\circ}29'E]$, 21 Oct. 1997, *Sangaji & Barrow* 6 (K!). **SUMATRA UTARA:** E Coast, Silo Maradja, Asahan, May 1927, *Bartlett* 8132 (K!); E Coast, General region of Marbau, Bilah, near Bilah Pertama (Parbasiran), Feb. 1928, *Toroes* 200 (K!). **SUMATRA BARAT:** Sumatra Barat, Sijunjung, Muro Kulampi, 200 m elev., 26 Feb. 1974, *Dransfield* 3957 (K!); Bengkulu, Ketahun, 40 m elev., 26 Dec. 1984, *Uhaedi* 019 (K!); Pakajumbuh, Taram, sandstone region of R. Tjampo, 500 m elev., 23 Aug. 1957, *Meijer* 6881 (K!). **JAMBI:** Jambi, Batang Tebopandak, 300 m elev., $[1^{\circ}38'S\ 101^{\circ}38'E]$, Sept. 1993, *Trichon* 801 (K!). **LAMPUNG:** Lampung, NW of Kota Agung, 350 m elev., $[5^{\circ}23'S\ 104^{\circ}25'E]$, 18 May 1968, *Jacobs* 8482 (K!). **MALAY PENINSULA. JOHOR:** Endau, between Bukit Petar and Sungai, 7 Sept. 1987, *Gianno* 151 (A, BISH, BO, K!, KEP!, L, LAE, P, PNH, SAN, SAR, SING!, TI, TNS, UC, US); Mersing, Gunung Arong Forest Reserve Cpt. 9, 20 m elev., $[2^{\circ}32'N\ 103^{\circ}47'E]$, 13 June 1977, *Dransfield* 5064 (K!); Ulu Kahang, 106.68 m elev., 2 June 1923, *Holttum* 10916 (K!). **PAHANG:** Aur Forest



Map 9. Distribution of *Korthalsia rostrata*. Dots are point localities of specimens examined.

Reserve, 38 miles inland from Kuala Rompin, 50 m elev., [3°6'N 103°6'E], 24 July 1975, *Dransfield* 4583 (K!). **PERAK:** Ipoh, Kinta Hills Forest Reserve, Compt. 78, near Ampang valley bottom, 350 m elev., 8 July 1975, *Dransfield* 4477 (K!); Kuala Kangsar, Gunung Bubu Forest Reserve Cpt. 77 Ulu Trong, 250 m elev., [4°44'N 101°22'E], 18 Nov. 1977, *Dransfield* 5381 (K!); Larut, 152.4 m elev., Oct. 1883, *Dr King's collector* 5047 (K!); Ridge of main range near Kampung Temakah, downstream from Pos Legap, Sungai Plus, 10 Jan. 1988, *Gianno* 320 (A, BISH, BO, K!, KEP!, L, LAE, P, PNH, SAN, SAR, SING!, TI, TNS, UC, US). **SELANGOR:** Semenyih, Sungai Lalang Forest Reserve, 200 m elev., [3°4'N 101°52'E], 22 April 1977, *Dransfield* 4950 (K!). **MELAKA:** *Griffith* s.n. (BR, K!). **TERENGGANU:** Besut, Ulu Setiu Forest Reserve foothills of Gunung Lawit, 100 m elev., [5°8'N 102°18'E], 3 Aug. 1977, *Dransfield* 5142 (K!). **SINGAPORE.** Nee Soon Swamp Forest, [1°23'N 103°48'E], *Rajasegar & Loo* 24 (K!); MacRitchie Forest, 17 m elev., [1°20'N 103°49'E], 11 Dec. 2014, *Shahimi* 25 (K!, SING!). **BORNEO. BRUNEI. BELAIT:** Sungai Liang, Sungai Liang Arboretum Reserve, [4°41'N 114°29'E], *Wong* 137 (K!). **TEMBURONG:** Temburong R. Valley, in area of river bed near helicopter pad, 50 m elev., [4°48'N 115°3'E], *Johns* 7282 (K!); Jalan Tengah 1850 m from N end, 100 m elev., [4°43'N 115°4'E], 1 Aug. 1991, *Stockdale* 14 (K); Amo, Temburong R. upstream from the Wong Nguan gorge, 500 m elev., [4°37'N 115°6'E], 10 April 1990, *Wong* 1738 (K!); Amo, Kuala Belalong, 300 m elev., [4°32'N 115°9'E], 14 Feb. 1992, *Dransfield* 7064 (K!); Bukit Belalong, N ridge, [4°29'N 115°11'E], 20 July 1989, *Wong* s.n. (K!). **INDONESIA. KALIMANTAN TENGAH:** near Rekut base camp, 250 m elev., [0°2'S 114°6'E], 11 April 1992, *Awmack* 299 (K!). **KALIMANTAN TIMUR:** Berau, RKT 92-93, Inhutani I Concession, 250 m elev., 8 Dec. 1991, *Stockdale* 137 (K!); near Sedulan, c. 50 km N of Sebulu, 27 Dec. 1978, *Mogea et al.* 1535 (K!); surrounding WWF basecamp Kayan Mentarang Reserve, 350 m elev., [2°51'N 115°55'E], 23 Nov. 1991, *van Valkenburg* 1055 (K!); about 30 km N of Sebulu, 30 Dec. 1978, *Mogea et al.* 1548 (K!); Kalimantan, Sintang, HPH km 86 – 85, along subsidiary road S towards Riam Batang, 80 m elev., [0°49'S 112°3'E], 4 May 1994, *Church* 1302 (K!); Kelian, K. Equatorial Mining area, 250 m elev., [0°20'S 115°55'E], 17 March 1997, *Kessler* 2080 (K!, L). **KALIMANTAN SELATAN:** Sungai Dusun, [1°48'S 114°31'E], *Muller* s.n. (L!). **MALAYSIA. SABAH:** Tawau, St Lucia, Rangu, Mile 10, State forest, 18 Sept. 1949, *Cuadra* 2383 (K!, KEP!); Tawau, Membalua Forest Reserve, 50 m elev., [4°16'N 118°0'E], 3 Nov. 1979, *Dransfield et al.* 5855 (K!, SAF, SAR); Mile 46, Nabawan, 400 m elev., 11 Sept. 1979, *Dransfield et al.* 5636 (K!, KEP, L, SAF, SAR); Telupid, c. 5 miles on

road Telupid-Karamuak, 24 Oct. 1979, *Dransfield et al.* 5798 (K!, SAF, SAR). **SARAWAK:** *Lobb* 106 (K!); Kapit, 7th Division, 8 km Logging Camp Nanga Mujong, 28 Aug. 1985, *Saigol* 35 (K!); Kuching, 1st Division, Sungai Sendok, Proposed Matang National Park, Matang, 10 May 1987, *Hock* 53881 (K!, L, NY); 1st Division, Wildlife Observation Path, Bako National Park, 19 Aug. 1975, *Jawa* 36609 (K!, L, NY, SAN); Gunung Gading, Lundu Distr., [1°43'N 109°49'E], 17 April 1996, *Ara* 73906 (K!, SING!); Gunung Santubong, 100 m elev., [1°44'N 110°20'E], 6 June 1964, *Ashton* 21471 (K!, NY); Lubok Antu, 2nd Division, Delok R., on steep slope in secondary forest near Nanga Sumpa, 150 m elev., [1°20'N 112°10'E], 4 June 1993, *Christensen* 1183 (K!); Miri, Gunung Mulu National Park, 4th Division, proposed extension, hills near Gunung Buda, 250 m elev., 14 Oct. 1977, *Dransfield* 5322 (K!); Miri, Gunung Mulu National Park, 4th Division, lower slopes of Gunung Mulu near Camp 1, 250 m elev., [4°5'N 114°53'E], 5 Oct. 1977, *Dransfield* 5272 (K!, NY, L); Serian, 1st Division, Sabal Tapang Forest Reserve Mile 70, 250 m elev., 19 May 1981, *Dransfield et al.* 6085 (K!, L, NY); 4th Division, Dulit Range, 350 m elev., 9 Oct. 1983, *Awa* 46688 (K!, L); Wooded slopes of Mt Mattang above water works, 31 Dec. 1963, *Moore* 9084 (K); 5th Division, Path to Bukit Pagon, Limbang, 29 July 1984, *Awa* 47554 (K!, KEP!); 3rd Division, Sungai Masoh, rumah Nyaving, Kuala Linau, Ulu Belaga, 200 m elev., 9 Aug. 1975, *Dransfield et al.* 4680 (BH, K!, KEP, L, SING!); Semenggoh Forest Reserve, 12 miles from Kuching, 20 Dec. 1955, *Tomlinson* 6 (K); Semenggoh arboretum, [1°23'N 110°32'E], 9 Feb. 1995, *Baker* 514 (K!, KEP!); 1st Division, Kampung Gayu, 250 m elev., [1°13'N 110°21'E], 15 July 1993, *Bunker* 30 (K!); 1st Division, Kampung Kakeng, 200 m elev., [1°9'N 110°27'E], 20 July 1993, *Bunker* 33 (K).

HABITAT. Occurs in a variety of habitats including lowland and hill dipterocarp forest and Kerangas forest.

VERNACULAR NAMES. *Wi cit* (Iban), *Wi Semut* (Iban), *Uwai merah* (Dusun), *Rotan kawan* (Aceh), *Wee pak lavo* (Kayan), *Laku sepuru* (Punan), *Uei saman* (Kenyan), *Lempinit ralun* (Murut), *Wi nang* (Iban), *Rotan seru* (Iban), *Rotan semut* (Iban).

USES. Stems used for weaving basket and mats.

NOTES. The widespread *Korthalsia rostrata* is easily confused with the more narrowly distributed *K. furtadoana*, which occurs only in Borneo (Brunei, Kalimantan and Sabah). When fertile, *K. rostrata* can be distinguished by its rachillae which are slender compared to the robust rachillae of *K. furtadoana*. However, vegetatively the two species are extremely similar, although fine differences can be detected. *Korthalsia rostrata* tends to have small, almost rounded ocreas compared to *K. furtadoana*. The leaflets of

K. furtadoana also have conspicuous, fine and closely spaced transverse veinlets.

In Brunei, a form of *Korthalsia rostrata* occurs that has lanceolate rather than rhomboid leaflets. Although the shape of leaflets is distinctive, the form appears otherwise to be identical to remaining forms of *K. rostrata*.

Korthalsia rostrata is inhabited by ants of *Camponotus contractus* (Moog *et al.* 2003), and of the genera *Dolichoderus* and *Pholidris* (Chan *et al.* 2012).

9. *Korthalsia scaphigeroides* Becc. (Beccari 1909: 619).
Type: Philippines, Mindanao, Zambo-anga, 1 July 1906, Hutchinson 4816 (holotype FI: isotype NY!, US!).

Slender, clustering rattan climbing to c. 5 m. Stem with sheaths c. 10 mm diam., without sheaths c. 8 mm diam.; internodes 9–23 cm. Leaf c. 1.5 m long including cirrus and petiole; sheath brown, with caducous, grey-black

indumentum, sheath armed with scattered abundant, brown, triangular spines, spines 2–7 mm long, c. 2 mm wide; ocrea 4.5–10.0 × 1.5–2.5 cm, conspicuous, elongate and inflated, clasping the stem, tough, brown, armed with 1–5 mm long tiny triangular spines, abundant black ants nested within the ocrea, entry hole made by ants visible; cirrus c. 45 cm, armed with recurved grapnel spines organised in whorls; petiole 9.7–13.0 cm, 5–6 mm wide and c. 3 mm thick at base, flattened adaxially, abaxially rounded, with brown indumentum as sheath, sparsely armed with spines as sheath; rachis 35–38 cm, armed with recurved grapnel spines; 4 leaflets each side of rachis, regularly arranged, rhomboid, mid-leaf leaflets 17.0–27.0 × 6.0–7.6 cm, leaflet dark green above, glabrous, with caducous, chalky-white indumentum on undersurface, distal margin conspicuously praemorse, transverse veinlets conspicuous, moderately closely spaced, 1.0–1.5 mm. Inflorescence not seen. Flower not seen. Fruit not seen. Seed not seen (Fig. 14).



Fig. 14. *Korthalsia scaphigeroides*. A leaflets (Baja-Lapis 112); B ocrea (Baja-Lapis 112).

DISTRIBUTION. Philippines (Mindanao) (Map 10).

SPECIMENS EXAMINED. PHILIPPINES. MINDANAO: Agusan del Sur, Trento near Simulao, 100 m elev., [8°3'N 126°4'E], 18 July 1984, *Fernando* 411 (K!); Agusan del Sur, Experimental Forest, FORI, [8°2'N 126°3'E], *Baja-Lapis* 112 (K!); Surigan, April 1915, *Ponce* 23913 (K!); Zambo-anga, [6°55'N 122°4'E], 1 July 1906, *Hutchinson* 4816 (FI, NY!, US!).

HABITAT. Growing in dipterocarp forest at low altitude.

VERNACULAR NAME. *Kaporigid* (Philippines).

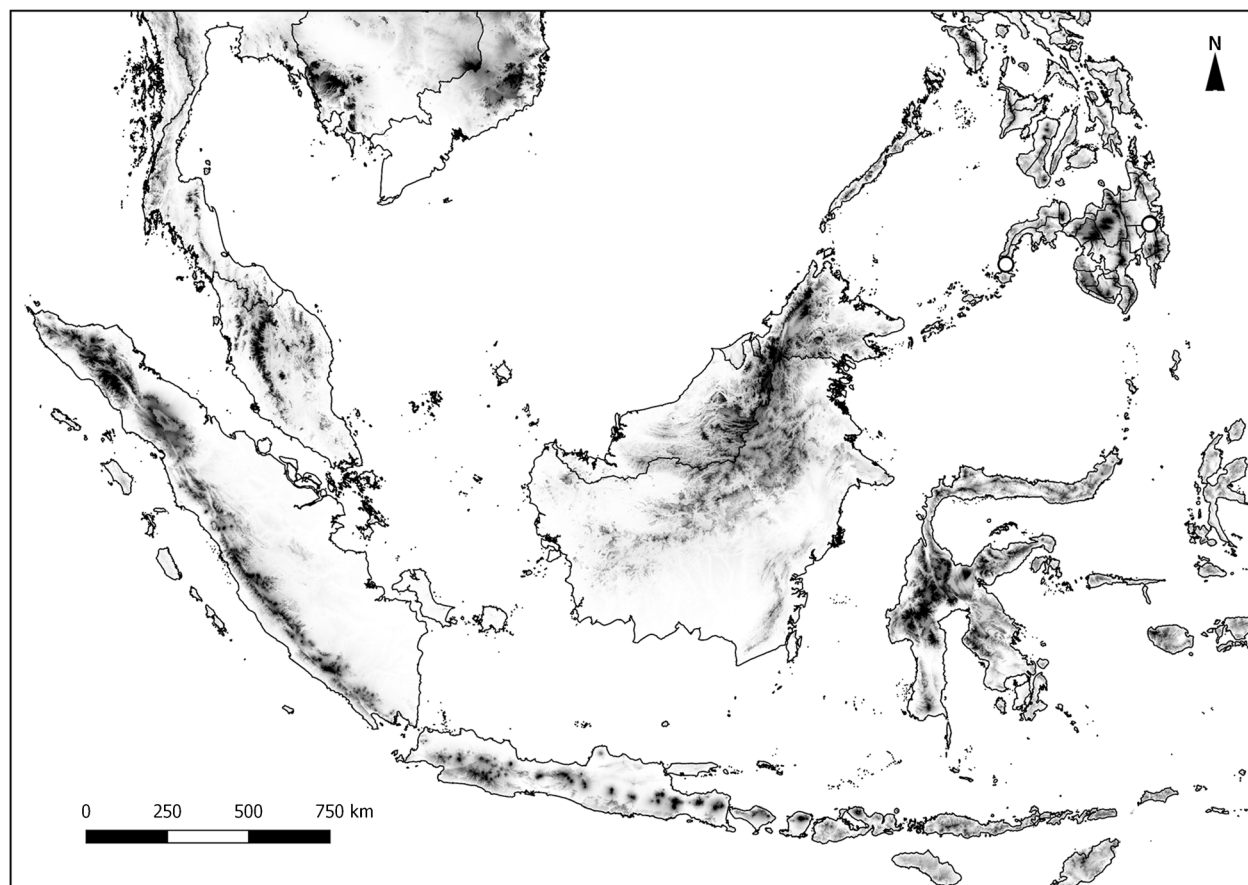
USES. Furniture and basket making.

NOTES. This species is still known only from sterile material. There is very little herbarium material available. Although *Korthalsia scaphigeroides* is quite similar to *K. rostrata*, it has ocreas more than 5 cm longer than those of *K. rostrata* and the abaxial surfaces of leaflets have very dense chalky white indumentum.

10. *Korthalsia scortechinii* Becc. in J. D. Hooker (1893: 475). Type: Malaysia, Perak, *Scortechinis.n.* (holotype FI!).

Clustering rattan climbing to 20 m. Stem with sheaths 20 – 25 mm diam., without sheaths 10 – 15 mm diam.;

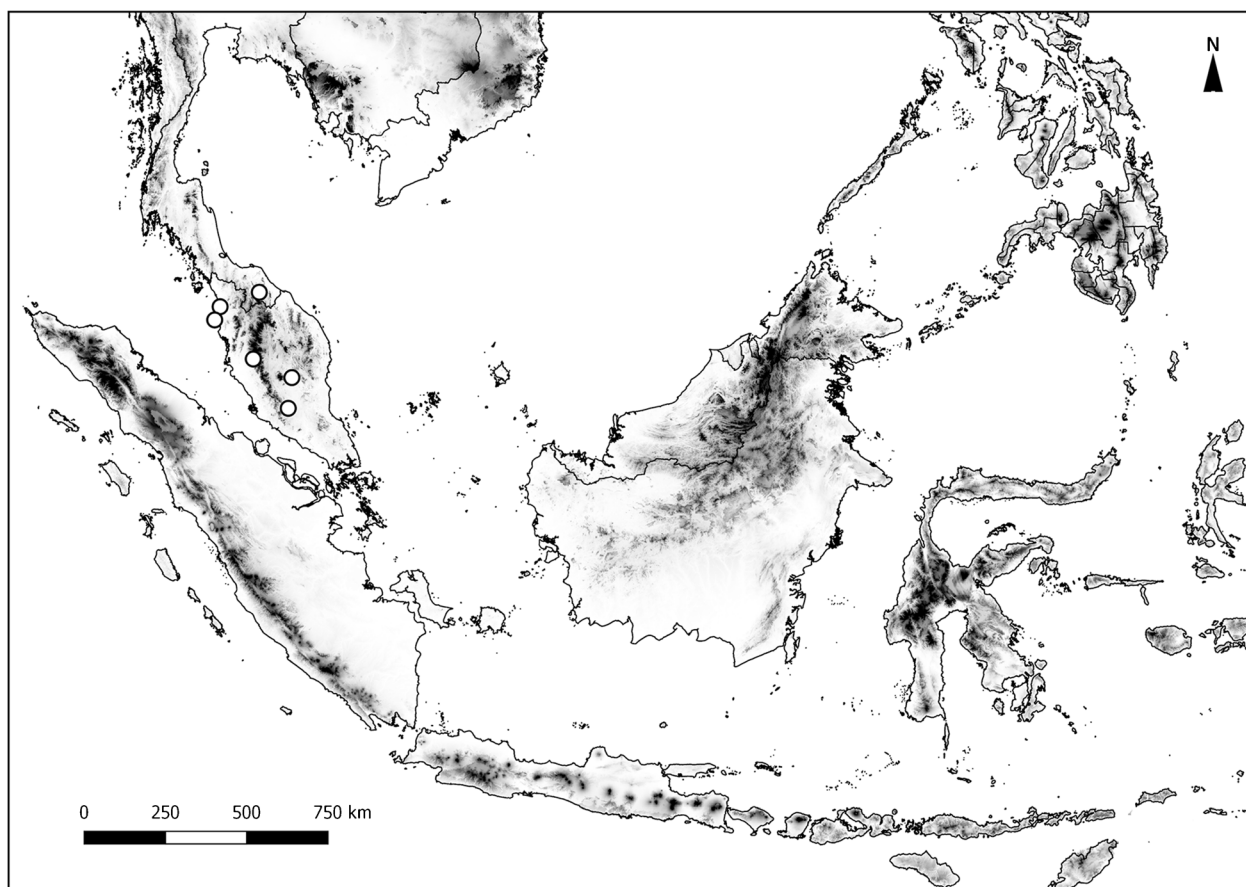
internodes 25 – 30 cm. Leaf 1.0 – 2.5 m long including cirrus and petiole; sheath green, almost entirely obscured by ocrea, with caducous, grey-black coloured indumentum, sheath sparsely armed with scattered short brown triangular spines, spines 1 – 4 mm long, 1.0 – 1.5 mm wide; ocrea 8 – 15 × 4 – 5 cm, conspicuous, swollen and elongate, base of ocrea tightly sheathing, margin tattering (net-like) (for some specimens), clasping the stem, tough, dull pale brown with caducous, chocolate indumentum, armed with 1 – 3 mm long, scattered short tiny triangular caducous, chocolate spines, numerous black ants within the ocrea; cirrus 0.30 – 1.25 m, armed with recurved grapnel spines organised in whorls; petiole 5 – 10 cm, 10 – 18 mm wide and c. 4 – 5 mm thick at base, flattened adaxially, abaxially rounded, indumentum, sparsely armed with spines; rachis 0.45 – 1.15 m, armed with recurved grapnel spines organised in whorls; 8 – 13 leaflets each side of rachis, regularly arranged, narrowly rhomboid, mid-leaf leaflets 21.5 – 30.1 × 2.5 – 5.2 cm, leaflet dull to dark green above, glabrous, with whitish indumentum on undersurface, distal margin conspicuously praemorse, transverse veinlets moderately conspicuous, moderately closely spaced, 1.0 – 1.5 mm. Inflorescence lax, 40.5 – 72.7 cm long including c. 6 mm peduncle,



Map 10. Distribution of *Korthalsia scaphigeroides*. Dots are point localities of specimens examined.



Fig. 15. *Korthalsia scortechinii*. A habit; B ocrea; C leaflets (Shahimi 15); D inflorescence (Dransfield 4976).



Map 11. Distribution of *Korthalsia scortechinii*. Dots are point localities of specimens examined.

branched to 2 orders; prophyll c. 4.0×0.7 cm, with caducous, dark brown indumentum; rachis bracts up to $4.1 - 9.0 \times 1.7 - 3.7$ cm, splitting, with caducous, dark brown indumentum with several tiny spines; primary branches 2 – 4, 5.7 – 10.6 cm apart; proximal primary branch 26.2 – 30.7 cm long, with up to 2 – 3 rachillae; rachillae 14.0 – 28.2 cm long and slender, including 0.5 – 1.0 cm visible stalk, c. 0.7 cm wide, lacking hairs between rachilla bracts. *Flower* not seen. *Fruit* $1.6 - 1.7 \times 1.1 - 1.5$ cm covered in 16 – 19 vertical rows of orange-brown scales. *Seed* 1.3×0.7 cm, endosperm ruminant (Figs 2B, 3B, 15).

DISTRIBUTION. Malay Peninsula, Thailand (Map 11).

SPECIMENS EXAMINED. THAILAND. NARATHIWAT: Si Sakhon, 550 m elev., $[6^{\circ}11'N 101^{\circ}30'E]$, 7 March 2001, Niyomdham & Puudjaa 6446 (K!). **MALAY PENINSULA.**

MALAYSIA. KEDAH: Sungai Patani, Gunung Jerai, 600 m elev., $[5^{\circ}47'N 100^{\circ}25'E]$, 6 July 1977, Dransfield 5106 (K!). **NEGERI SEMBILAN:** Pasoh Forest Reserve, 100 m elev., $[2^{\circ}58'N 102^{\circ}18'E]$, 9 May 1977, Dransfield 4976 (K!). **PAHANG:** Genting Highlands, 30 Jan. 1995, Baker 497 (KEP!); Kuala Lipis, 18 Aug. 1925, Somerville 10484 (K!); Tasak Bera, $[3^{\circ}49'N 102^{\circ}24'E]$, 3 Sept. 1982, Gianni 512 (K!). **PENANG:** Penang Hill, 423 m elev.,

$[5^{\circ}25'N 100^{\circ}16'E]$, 3 March 2014, Shahimi 15 (K!, KEP!). **PERAK:** Tapah, 700 m elev., $[4^{\circ}20'N 101^{\circ}20'E]$, 23 Oct. 1982, Ave 178 (K); *Scortechini* s.n. (FI!).

HABITAT. Lowland and hill dipterocarp forest up to 900 m altitude.

VERNACULAR NAMES. *Rotan dahan* (Iban), *Rotan semut*, *Wai doa* (Thailand).

USES. Cane used to make baskets, also as binding material.

NOTES. *Korthalsia scortechinii* has sometimes been confused with *K. echinometra* because of the large swollen inflated ocrea, but can be distinguished by the ocrea bearing numerous short triangular spines (not long narrow spines) and the narrowly rhomboid leaflets (not lanceolate leaflets).

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References

- Baker, W. J., Dransfield, J. & Hedderson, T. A. (2000). Phylogeny, character evolution, and a new classification of the Calamoid Palms. *Syst. Bot.* 25: 297 – 322.
- ____ & Dransfield, J. (2002). *Calamus longipinna* (Arecaceae: Calamoideae) and its relatives in New Guinea. *Kew Bull.* 57: 853 – 866.
- ____ & ____ (2006). *Field Guide to the Palms of New Guinea*. Kew Publishing, Royal Botanic Gardens, Kew.
- Beccari, O. (1884). Piante ospitatrici. *Malesia, raccolta d'osservazioni lese e papuano* 2: 62 – 78.
- ____ (1893). Order CLXIII-Palmae. In: J. D. Hooker, *Flora of British India* 6: 475. L. Reeve, London.
- ____ (1909). Notes of Philippines palms II. *Philipp. J. Sci.* 4: 619 – 620.
- ____ (1918). Asiatic palms — Lepidocaryeae, Part III, The species of *Korthalsia*. *Ann. Roy. Bot. Gard. (Calcutta)* 12 (2): 104 – 155.
- Bequaert, J. C. & Wheeler, W. M. (1922). Ants in their diverse relations to the plant world. *Bull. Amer. Mus. Nat. Hist.* 45: 333 – 583.
- Blume, C. L. (1843). De Ceratolobo de Korthalsia. *Rumphia, sive commentationes botanicae imprimis de plantis Indiae orientalis: tum penitus incognitis tum quae in libris Rheedii, Rumphii, Roxburghii, Wallichii aliorum recensentur* 2: 166 – 173.
- Chan, C. S.Y., Cheng, J., Loh, J. Y. Q., Tan, E., Loo, A. H. B. & Tang, J. H. (2012). Observations of ants and aphids in the rattan species *Korthalsia echinometra* Becc. and *Korthalsia rostrata* Blume. *Raffles Bull. Zool.* 25: 133 – 139.
- Couvreux, T. L., Kissling, W. D., Condamine, F. L., Svenning, J. C., Rowe, N. P. & Baker, W. J. (2015). Global diversification of a tropical plant growth form: environmental correlates and historical contingencies in climbing palms. *Front. Genet.* 5: 452.
- Dransfield, J. (1979). *A Manual of the Rattans of the Malay Peninsula*. Forest Department, Ministry of Primary Industries, Kuala Lumpur.
- ____ (1981). A synopsis of the genus *Korthalsia* (Palmae: Lepidocaryoideae). *Kew Bull.* 36: 163 – 194.
- ____ (1984). *The Rattans of Sabah*. Sabah Forest Record No. 13. Forest Department, Sabah.
- ____ (1986). A guide to collecting palms. *Ann. Missouri Bot. Gard.* 73: 166 – 176.
- ____ (1992). *The rattans of Sarawak*. Royal Botanic Gardens, Kew.
- ____ (1997). *The rattans of Brunei Darussalam*. Ministry of Industry and Primary Resources, Brunei Darussalam.
- ____ & Baker, W. J. (2003). An account of the Papuan species of *Calamus* (Arecaceae) with paired fruit. *Kew Bull.* 58: 371 – 387.
- ____, Uhl, N. W., Asmussen, C. B., Baker, W. J., Harley, M. M. & Lewis, C. E. (2008). *Genera Palmarum: The Evolution and Classification of Palms*. Kew Publishing, Royal Botanic Gardens, Kew.
- Edwards, D. P., Ansell, F. A., Woodcock, P., Fayle, T. M., Chey, V. K. & Hamer, K. C. (2010). Can the failure to punish promote cheating in mutualism? *Oikos* 119: 45 – 52.
- Furtado, C. X. (1951). Palmae Malesicae, XI —The Malayan species of *Korthalsia*. *Gard. Bull. Singapore* 132: 300 – 324.
- Griffith, W. (1850). *Palms of British East India*. C. A. Serrao, Calcutta.
- Henderson, A. (2009). *Palms of southern Asia*. Princeton University Press, New York.
- ____ & Nguyen, Q. D. (2013). A new species of *Korthalsia* (Palmae) from Laos and Vietnam. *Palms* 57(3): 150 – 154.
- Holmgren, P. K., Holmgren, N. H. & Barnett, L. C. (1990). *Index Herbariorum*. Part I: The herbaria of the world. 8th edition. New York Botanical Garden, New York.
- Hooker, J. D. (1893). *The flora of British India*. Volume 6. L. Reeve & Co. London.
- Lapis, A. C. (2010). *A field guide to Philippine rattans*. Rushing Water Publisher Ltd., Laguna.
- Martius, C. F. P. von. (1845). *Historia naturalis palmarum* 3 (2): 211. T. O. Weigel, Lipsiae.
- Mattes, M., Moog, J., Werner, M., Fiala, B., Nais, J. & Maschwitz, U. (1998). The rattan palm *Korthalsia robusta* Bl. and its ant and aphid partners: studies of a myrmecophytic association in the Kinabalu Park. *Sabah Parks Nat. J.* 1: 47 – 60.
- Merklinger, F. F., Baker, W. J. & Rudall, P. J. (2014). Comparative development of the rattan ocrea, a

- structural innovation that facilitates ant-plant mutualism. *Pl. Syst. Evol.* 300: 1973 – 1983.
- Miquel, F. A. W. (1868). De palmis Archipelagi Indici observations novae. *Verh. Kon. Akad. Wetensch., Afd. Natuurk.* 11 (5): 1 – 33.
- Moog, J., Fiala, B., Werner, M., Weissflog, A. & Maschwitz, U. (2003). Ant-plant diversity in Peninsular Malaysia, with special reference to the Pasoh Forest Reserve. In: T. Okuda, K. Niiyama & S. Thomas (eds), *Pasoh: Ecology and Natural History of a Southeast Asian Tropical Rainforest*, pp. 459 – 494. Springer, Tokyo.
- Ridley, H. N. (1907). *Materials for a Flora of the Malayan Peninsula* 2. Methodist Publishing House, Singapore.
- Shahimi, S. (2018). *Systematics and evolution of the rattan genus Korthalsia Bl. (Arecaceae) with special reference to domatia* (PhD thesis). University of Reading, Reading.
- Sunderland, T. C. H. (2004). Ant and rattan associations in forest of tropical Africa. *Ghana J. Forest.* 15(16): 13 – 19.
- (2012). A taxonomic revision of the rattans of Africa (Arecaceae: Calamoideae). *Phytotaxa* 51: 1 – 76.
- Teijsmann, J. E. & Binnendijk, S. (1866). *Catalogus Plantarum quae in Horto Botanico Bogoriensi Coluntur*. Ter Lands-Drukkerij, Batavia.
- Vorontsova, M. S., Clark, L. G., Dransfield, J., Govaerts, R. & Baker, W. J. (2016). *World Checklist of Bamboos and Rattans*. International Network of Bamboo and Rattan & Royal Botanic Gardens, Kew.
- Wendland, H. (1859). *Bot. Zeitung (Berlin)* 17: 174 – 175.
- WCSP (2017). *World Checklist of Selected Plant Families. Facilitated by the Royal Botanic Gardens, Kew*. Published on the Internet; <http://apps.kew.org/wcsp/> Retrieved October 27, 2017.

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